SCIENCE

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THE TRAINING OF CHEMISTS[1]

THE address of Dr. Whitney on research, which follows mine, deals with that aim of the chemist which always receives the most enthusiastic recognition, namely, the elaboration of the content of the science, the farther coordination of that content, and the expansion of the boundaries of chemistry. But thorough *training* is indispensable before original work can begin. A genius, without adequate training, seems to know by instinct what information he needs and where to find it. He devises new methods when those which he has learned fail. He reaches the goal, in spite of all handicaps. Better training would have saved him some needless loss of time, but often would not have improved the final result. Geniuses, however, are few and far between. The advancement of the science would be fitful if it depended upon them alone. The greater part of the additions to chemical knowledge are made by men with an aptitude for the science, it is true, but with nothing approaching genius of the higher order. With them, the thoroughness of the previous training is, therefore, a very potent factor. At the other extreme, in the case of the chemist who does mainly routine analyses, who corresponds to the draftsman as distinct from the architect, the training he received must determine largely the value of his results. In all the intermediate cases, where intelligent study of an individual situation is demanded, and new adaptations to special purposes are required, training in the prin-

[1] Address delivered in Urbana at the opening of the Chemical Laboratory of the University of Illinois, April 19, 1916.

ciples of the science and previous exercises in applying them to new cases, with the alertness and mental adaptability which such training produces, are the chief factors in success. The training of chemists is therefore a matter well worthy of careful study.

It is not my purpose to discuss the subject as a whole. I desire rather to emphasize four points which, after nearly thirty years' experience as a teacher, I am inclined to think are of vital importance, yet receive too little consideration, and indeed are often entirely ignored.

Overlapping Courses.—Take, for example, the treatment of the freshman who, on entering a college or university, offers chemistry for admission. In the vast majority of cases he is placed in the same class with those who have never studied the subject before. All agree that the result is unsatisfactory, but many attribute this result to the wrong cause. They say that the chemistry of the high school is valueless, and that their pupils would be better off without it. The actual fact is that to such pupils the introductory parts of the course seem trivial and boresome. They become indifferent. Later, when matter suited to more mature minds comes up, they do not observe the change. Soon they fall behind the beginners, and finally they barely pass in the course, if they pass at all. The result is not the fault of the student or of the high school, however—it is an inevitable result of ignoring the most familiar features of human psychology. Administer the admission requirement with reasonable strictness, place those credited with chemistry in a class or section *by themselves,* make them feel from the start that they are getting something that is new to them, and they will respond accordingly. Of course, elementary matters can not be omitted. No two members of the class come from the same school, their training is very diverse, and there is hardly one fact, no matter how simple, which is known to every one. The elements must be reviewed at the same time that new matters are introduced. But a pace much more rapid than that of the beginners can be maintained. In Chicago, my experience showed that this class secured in two quarters a much better knowledge of chemistry than a class of beginners could obtain, under the same conditions in three quarters.

If the school course is valueless, why give admission credit for it? If it represents a real advance into the science, as experience shows that it does, why ignore it? Why not accept it and start at the higher level? Overlapping of courses is all too common in chemical training, and it often begins by duplicating all the work of the high school, and not taking it for granted and proceeding beyond it.

Overlapping affects many of the later courses in every university. The instructor in qualitative analysis, instead of ascertaining exactly what is taught in the inorganic course preceding it, and confining himself to the briefest possible references to what he has a right to assume as known, too often spends many hours repeating such parts of the elementary facts and such elementary principles as are required in his work. I have known of instructors in quantitative analysis who ignored all the content of the previous instruction—both facts and theory —and reduced the subject to a series of mechanical processes, which could have been performed equally well (or equally badly) by a beginner. The students respond quickly to this situation, just as in other circumstances they would respond to demands on their previous training, and soon work with due lack of intelligence. Thus not only may the previous training remain unused, where continuous and most effec-

tive use could have been made of it and much might have been added, but, being unused, it is soon forgotten. At the end of two or three years of work, the pupil may actually know less of the science than he did at the end of the first year. Even if each course only overlaps about half of the preceding course, the inevitable result is that the pupil gains in four years only what, with better coordinated instruction, he could have secured in two years.

Curiously enough, the opposite fault affects much of our organic chemistry. Here the books, instead of striving to link the subject intimately with inorganic chemistry, and thus aiming at continuity, too often give the subject as far as possible the appearance of a different science. Unfortunately the instructors often follow the same lead. I have known cases where a law of chemistry was hardly ever mentioned, an experiment was never shown, a substance was almost never exhibited, and the only chemical material in evidence was pulverized gypsum in streaks and curves on a black background. There are notable exceptions, of course, but too much so-called organic chemistry is nothing but riot of symbols and "bonds." Some overlapping is necessary here, to offset the real differences in the nature of many of the reactions and of many of the experimental methods. The course might well be made essentially a part of the elementary general chemistry, and less like a separate science.

In respect to loss of time by overlapping, the university, with its numerous instructors, is at a disadvantage when compared with the college. In the latter, three or four years of chemistry are all given under the immediate direction of one man, and continuous work and rapid progress by the pupil are more likely to be secured.

Standard Courses.—In different institutions in which the training in chemistry serves the very same purposes, there is too little agreement in regard to the weight, the content, and the quality of the regular courses. In many universities and colleges, the course in inorganic chemistry based on high-school chemistry is standardized, and demands two or three class-room periods and six hours of laboratory work weekly for twenty-four to twenty-eight weeks. But the graduates of one large university tell me that their course in this subject is inferior in quality and extent to the average high-school course, and that previous work in the science is neither required for admission to it nor recognized in any way when existent. Courses of all kinds, intermediate between these extremes, are common. Now, the establishment of a more uniform standard is most desirable for many reasons. Migration from one school to another is rapidly increasing. Schools of medicine are requiring previous college work, but the boy who has had about half a course each in inorganic chemistry and qualitative analysis or organic chemistry can neither be admitted, nor can he be directed to any course in which his peculiar deficiencies can be made up. The student who decides to move to a school of engineering often finds that he has been provided with a similarly extensive, but superficial preparation which leaves him a misfit. When the student attempts graduate work in another institution, he encounters the same handicap. Of course, a slight course in inorganic chemistry can be followed only by a course in mechanical qualitative analysis, such as prevailed forty years ago, and any attempts in each successive course to develop a grasp of the modern aspects of the science must be given up. A separate and distinct course in physical chemistry, taken later, can never solve the problem. In such a course, only a few illustrations can be

given, whereas continuous application of the same principles in study and in the laboratory during the whole training is necessary to success. The student keeps the different courses in separate, water-tight compartments in his mind, and only a genius will make the thoroughgoing applications and connections that are required to weld the whole into a science. Modern chemistry simply teems with applications of physical chemistry. This is the case both in the laboratory and in the factory, both in the biochemistry and physiology of the school of medicine and in the courses required of the student in chemistry and chemical engineering. The institutions of learning must respond to the obvious demand. We are not training students to use four or six years hence even the chemistry of to-day, much less the chemistry of 1880 or 1890. We are training them to understand the chemistry and biochemistry of the future and to apply and expand the science as it will be several years hence. All that we know for certain about that chemistry is that it will be less capable of mechanical, unintelligent use than the chemistry of the past, and that ability to apply theoretical conceptions will be more desirable, nay indispensable, than ever. Standardizing our elementary courses, both as to extent and as to character, is an essential part of preparedness to meet the demands of the future.

In this connection, a word in regard to the training of candidates for the degree of Doctor of Philosophy, a class of students which is rapidly increasing in numbers and importance, is in place. Their training in the fundamental branches of chemistry is at present very various and unequal in quality, even when sufficient in quantity. They can take advanced courses, but piling knowledge on a shaky foundation is unwise. The advanced principles can perhaps be used, albeit mechanically, when, as given, they happen exactly to fit the problem. But when they have to be adapted to a different situation, only a chemist who has an absolutely sound understanding of the fundamental elements of the science can make the adaptation with certainty. We are all familiar with published researches which were, in reality, futile and valueless because fundamental principles were overlooked, or were not correctly brought into relation to the observations.

One remedy is to require graduate students to attend the elementary classes. This, however, is only a half-measure. Review courses in general chemistry, analytical chemistry, and organic chemistry, in which these subjects are examined in retrospect, can be given so as to occupy less time, and yet achieve the object much more effectively. Emphasis can be laid on application of modern views, the oddities which pervade most courses in chemistry can be discussed, a broader and more critical scrutiny of the principles can be undertaken. Of especial importance is the fact that the classification of the content of chemistry can itself be discussed, although with beginners the classification can only be *used*. Also, the reasons for preferring certain definitions and certain conceptions can be considered, and less advantageous or even erroneous statements commonly encountered can be brought out as they could not be in a class for beginners. We learn much more by a study of wordings that are open to criticism than by simply memorizing uncritically faultless ways of stating the same things. Thus, the preparation of the graduate student can be standardized also, at least in respect to its most essential features.

An Alternative to Lecturing.—In a lecture, one states the facts or explanations clearly and, *for the moment,* the attentive

student understands perfectly. But, is it our object to train him to understand statements made by others—does ability to do that constitute a knowledge of chemistry, and play an important part in making a chemist? Is a watchmaker a person who recognizes a watch when he sees it, who knows what makes it run, and when it is running well, or is he a man who can make and repair a watch? Is not a chemist one who can himself make correct statements about chemical topics, and can himself put together the necessary facts and ideas, and himself reach a sound chemical conclusion? Listening to a lecture keeps the student in a *receptive* attitude of mind, whereas the attitude we desire to cultivate in him is the precise opposite of this. The student should begin by himself acquiring the ability to state simple ideas correctly, and later himself practise putting facts and ideas together and reaching conclusions. The conclusions are not new, but going through the operation of reaching them for himself is new to the student. No one would explain to a group of people who were not musicians how the piano is played, and perform a few lecture experiments on the piano, and then be foolish enough to expect the audience to be able at once to play the same pieces themselves. Of course not, because we all know that every kind of mechanical dexterity has to be acquired by practise and by the formation of habits, nervous and muscular. But we do not all realize that mental operations are also *largely mechanical*. For the most part they are made up of half-unconscious responses, each of which is an idea previously acquired by practise, and only the selection of the units of which the whole mental operation consists and the arranging of them in due order are the results of actual thought and conscious reasoning. After explaining some point to the class, such as the reasons in terms of the ion-product constant for the precipitation of calcium oxalate, one might assume that they all understood the explanation, and perhaps they all do. But ask them individually to *state* briefly the reason for the precipitation, and some will make remarks that have no bearing on the subject, some will make partly incorrect statements, many will make statements that are correct so far as they go, but are incomplete. Only one student in thirty will give a correct and complete answer. Many of the others undoubtedly understand the matter perfectly, but unless they have an opportunity themselves to put the answer together, the impression will be slight and fleeting. It is the exercise of going through the reasoning and the wording of the answer, for oneself, that alone can make the impression a permanent one and fix the explanation in the mind.

Evidently, the pupil would better study the subject in the book, taking much or little time according as his powers of acquisition are slow or fast, until he can state each important point in his own words. Then the class-room work can be confined to testing the preparation, discussing difficulties, showing illustrative experiments, and asking questions about the cases illustrated. Before printing was invented, oral instruction was necessary. It seems to me that a good many university men have not yet realized that the printing press is now available. It is right that we should know the history of our profession, but not necessary to adhere to all the practises of antiquity. We all know walking was invented before the locomotive, but none of us walked to Urbana to this meeting. Was that thoroughly consistent?

I am not proposing to abolish lecturing. In courses taken by students who already know how to study, that is, in the more

advanced courses, lectures are of great value. They give a general view of the territory as a whole, they distinguish the more important from the less important items, and they enable the student to conduct his *own private study* of the subject with intelligence. I am referring mainly to the elementary course for freshmen, where not one member of the class in twenty has ever studied in the true sense, or has any knowledge of how to study. It is a part of the benefit he gets from the course that he learns how to study and acquires the necessary habits. Listening to lectures, in such a case, if the lectures are well constructed, only deludes him into thinking that he has fully grasped the subject, and *prevents* him from studying. Additional class-exercises given by assistants and subordinate instructors do not help the situation materially. Often the assistants do not keep in close touch with the mode of presentation of the lecturer. Always the students feel that, since assistants handle this work, it must be less important, and so it suffers in effectiveness. After trying both plans, it will be found that incomparably better results are obtained by giving two or more sections, of thirty to forty students each, to a competent instructor, and letting him conduct the whole work of each section. The lessons are assigned in advance, and due preparation is insisted upon.

There are other disadvantages of the lecture method for freshmen. The lecturer must adjust his speed to that of the slower, if not the very slowest members of the class, although many of its members could follow equally well if the pace were tripled. With the slower students spending more time in preparation, and this and the other variable factors thus relegated to the home study, the class becomes more uniform, and either twice as much ground can be covered in the hour, or the ground can be covered twice as thoroughly, according to the nature of the topic.

That the student has thus acquired a more thorough foundation in chemistry, and that he has learned how to study, are both of great advantage when the next course is taken. When the lecture method has been used, the students have still to be taught the necessity for continuous study and how to do it, and progress in the next course is slow. Then also, the fleeting impressions, detained temporarily by a few days of violent but superficial study just before the examination, have almost entirely evaporated, and overlapping and repetition of all the necessary facts and principles is an absolute necessity. For this reason, also, much time is lost. Efficiency demands that something of permanent value be accomplished *each year*, and there is every reason against postponing the application of efficient methods to the second year.

Again, questioning shows at once which points have been understood by all, and which points have remained unclear, and the time is spent on the latter. Also, the recollection of past topics, when the need of applying them arises, can be tested, misunderstandings can be recognized and removed, and lapses of memory can be remedied. The method finds out infallibly what is needed, and how much in each case is needed, and permits the doing of precisely what is necessary. The process involves continual measurement of the existing results. A lecturer can only guess at what is needed, and how much of it, and must necessarily be more or less in error on every occasion. The method advocated has for the chemist the attraction of being quantitative and, with practise, the experimental error becomes negligible.

Still again, since the lectures are sys-

tematic and orderly, while the laboratory work is necessarily more or less topical, the pupil thinks the lectures are the real kernel of the course. Yet, in point of fact, the real contact with the subject takes place in the laboratory, and it is better therefore to make the student feel that the laboratory work is the principal feature of the course, and that the class-room work is simply a discussion and adjustment of what he has learned in the laboratory and at home. Individual observation and reasoning from observation, can thus receive that strong emphasis which they deserve, but in a lecture can never receive. Naturally, every week each student must begin with the experiments for that week, since he can not otherwise prepare himself for the class meetings.

Finally, many chemists admit that they learned little chemistry from the first lecture course, but insist that the personality and point of view of the lecturer—not only in matters chemical, but in respects quite remote from that science—exercised a profound influence upon their own point of view and their subsequent attitude towards life. In reply, it need only be pointed out that, in the free interchange of thought which is a necessary part of the method suggested, the opportunity for the personality of the instructor to assert itself is even freer than it ever can be in a lecture, and that the digressions, if they are such, since they will usually be suggested by reactions shown by the students themselves, will be much more likely to strike some target effectively and forcefully than will the random shots of a lecturer, who knows only what is in his own mind, and nothing of what is in the mind of the listener.

Improved Laboratory Facilities.—The mechanical equipment of a chemical laboratory is an important efficiency factor in the training of chemists. There is perhaps no department in the college or university where the ratio of results achieved to time spent is so small. This is particularly true of the quantitative and organic laboratories, although it is conspicuous in all branches of the science.

For example, the evaporation of a solution on a steam bath may take five or six hours. The temperature of the liquid may never greatly exceed 90°. A vigorous attempt is made to train the student to carry on several operations simultaneously, but four or five months elapse before he learns to do this effectively. A plate covered with shot and heated with steam under pressure, one at each working place, will easily give a temperature of 130°. The time required for the evaporation will become a mere fraction of that required with an ordinary steam bath, and the saving of time will begin on the first day, instead of being postponed until months of training have brought about the same result by another method. The cost of fuel will also be less. When the dissolved substance is a very soluble one, the vapor pressure of the solvent becomes rapidly smaller as evaporation proceeds, and soon the steam escaping from a bath gives to the air a partial pressure of water vapor equal to the vapor pressure of the solution, and evaporation ceases. With the steam confined in the plate, so that saturation of the air is avoided, the evaporation will proceed much further without interruption. A tube connected with a vacuum system, provided on all desks, will remove the vapor, and will facilitate further evaporation beyond this point to a surprising degree. Desk ventilation is of course required when the steam plate is used.

Ventilation at each working place, as it has been installed in the new laboratory here, also permits much saving of time. Hoods take the student away from his desk

and reduce the number of operations he can carry on simultaneously. Hoods become dirty and unsightly, because no one student can be held responsible for their condition. They also furnish the students with an excuse for leaving their desks, and conversing about football, when they should be at work. In case a hood is really required, which seldom happens, a folding hood can be drawn from the supply-room and erected over the desk ventilator.

The traditional arrangement of chemicals on a side shelf is also open to many objections. Anywhere from ten to a thousand times as much of the chemical may be taken as the operation really requires, so that reckless habits are acquired and much material is wasted. When the class is following a program, and working on the same experiments, the same chemical is needed by several students at the same moment, and delays occur. For the same reason, certain bottles are quickly emptied. When one of the bottles is empty, it is not the business of any student to have it filled, and so another convenient excuse for conversation is provided. The side shelf furnishes opportunities for conversation far more plentifully than it does chemicals. With a little initial work by the instructor, a list of the amounts of each chemical and solution required for the term's work can be prepared, and each student can be provided with a kit of chemicals which he keeps in his desk. Professors Freas and Beans tried this plan first on a class in qualitative analysis, and the instructor added between twenty and twenty-five per cent. to the work of the course in order that the time thus saved might be utilized. The saving in the total quantity of chemicals consumed pays the expense of making up the kits, and the twenty to twenty-five per cent. additional training is all clear profit. Every student is entitled to the set of chemicals appropriate to his course. If he wishes to use more than the allowance, which should be ample, he can obtain them from the supply room and have them charged in his bill for breakage. Thus those who prefer to be extravagant pay personally for the privilege, and the appropriations at the disposal of the department are conserved and permit the offering of better facilities to all.

For example, in one term of a course in organic chemistry, one student used less than \$8 worth of chemicals, while the largest amount used was over \$28 for the performance of the same work. It was evident from this that \$12 worth of chemicals was ample, and that all students using more had been dissipating the resources of the department, and should hereafter be required to pay for the excess.

In a large laboratory, there are times of the day when the number of students trying to replace broken articles or to obtain other supplies at the stock room becomes great, and loss of time is the inevitable result. No institution of learning can afford to multiply skilled attendants, when they are needed only during a rush hour in the afternoon. On the other hand, the use of unskilled help leads to mistakes, involving loss of money by the department and loss of time by the student. The provision of more than one supply-room is an expensive remedy, and does not always prevent crowding. Instead of waiting twenty minutes or more for his turn, the student can in one minute write out his demand on the telautograph, and then return to his desk and go on with his work. A receiving clerk stamps the card in a calculagraph clock at the time the order comes in, and again when the boy returns after delivering the article and presents the same card signed by the student. The time required for filling the order need never exceed seven minutes: if

it does, the cause of the delay is investigated. Of course, a stock of supplies equal to all ordinary demands must be available, and in the larger laboratories this stock represents an investment of at least sixty to eighty thousand dollars.

In all laboratories, much glass apparatus is returned in dirty condition. Since it will not be accepted in this condition by another student, it can not be received. It is thrown away and the student's account is charged with its value. Installing dish-washing machinery will save the greater part of this expense and reduce materially the number of new articles to be ordered, received, unpacked, checked, and stored. In our own experience the substitution of a charge for washing, in place of a charge for the whole cost of the apparatus thrown away because of being dirty, as it had been made the year before, reduced the breakage bills for an equal number of students by nearly $1,200. During the year the apparatus of instructors and the apparatus used in lectures can be washed at one central place more economically than by scattered, unsupervised labor. Then too, in many courses, cleaning apparatus takes up much of the time of the student. A graduate student, who is paying tuition, room-rent, board and other living expenses, and who is sacrificing his earning power to obtain further education, can save time which has a high money value to him by sending his apparatus to the supply-room for cleaning.

Ring-stands and burners are usually painted with asphalt paint. This gives an exceptionally porous covering, especially fitted to permit access of laboratory gases and to hold moisture. One investigator finds that when more than two coats of paint have been applied, rusting is not retarded but accelerated. The sand blast will take off every trace of the paint with astonishing ease and thus, with a single coat of new paint, of a properly chosen kind, every article placed in the outfit will look as good as new. Ill-kept apparatus fosters careless work, while nice-looking apparatus guides the student, without his being conscious of the influence, into clean-cut and satisfactory manipulation.

The sand-blast reminds us that a mechanic and a workshop are necessary features of a large laboratory. One recent research by an eminent chemist indicated that he made an electroscope out of a tomato can tied to an empty Lydia E. Pinkham medicine box by means of tan-colored shoe laces of the latest model. A more efficient and durable instrument could have been made with the help of a mechanic, and much of the time the professor and student spent in trying to work with this aggregation would have been saved. It is more economical to purchase standard apparatus, but, when modified forms are required, when repairs are needed, and when new apparatus is devised for research, the mechanic, readily accessible in the building, is a necessity.

Another problem of the laboratory is to utilize the desk space during a larger proportion of the time. If many of the desks are to be used during only two afternoons in the week, and are to remain idle during four fifths of the working hours, one can not provide a desk for each student, with all the overhead cost for the building and plumbing which that implies. In some courses, three or four cupboards, each capable of holding the whole outfit, can be provided under each working space, and three or four students can be accommodated. But in many cases, as in quantitative analysis and organic chemistry, the outfit is extensive, and often only one student can use the desk. Yet the space is not really utilized. Most of the apparatus is placed on

the bottom of the cupboard and on the single shelf above—with the smaller articles in the drawers—and much empty space is provided above the apparatus, in order that articles at the back may be taken out without disturbing those in front. Can not some way be devised of saving this space, and at the same time making it unnecessary for the student to get down on his hands and knees on the floor to explore the dark recesses of the desk?

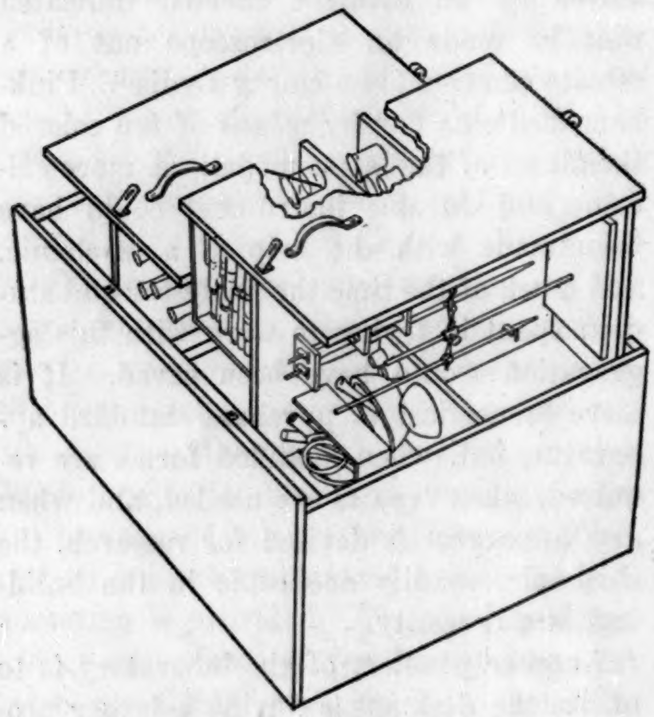

Fig. 1.

A desk designed by Dr. Fales seems to solve this problem (Fig. 1). The door is without hinges, and is pulled straight forward. Attached to it is a set of shelves and racks of the same width as the door, and extending to the back of the cupboard. These are planned so as to provide a place for each item in the outfit. This moves on a small wheel in the center of the foot of the door, and is supported behind by a wheel running in a brass-lined groove. Thus, when the front panel (or door) is pulled out, the whole rack comes out into the light, each side can be examined at a glance, and any article on it can be taken out in an instant. The outfit, placed in the box in which it is drawn from the supply-room, occupies 10,000 cubic inches. When set out in the rack, it occupies 24,000 cubic inches. When placed in the ordinary desk, with its cupboard and drawers, it occupies 44,000 cubic inches. Since in the rack-cupboard it thus occupies only about half the space commonly required, two outfits for two different students can go where one went before. In addition, actual measurement shows that the student can take out any needed article or chemical in one third of the time required with the common arrangement, and instead of taking 3-4 minutes (by measurement with a stop-watch) to ascertain that he does *not* have a chemical asked for by the instructor, he reaches the same conclusion with greater certainty in six seconds. The effort to pull out an ordinary laboratory drawer, when empty, requires by measurement, a force of four to twelve pounds. That necessary to draw forth the rack with its complete load of apparatus and chemicals (weighing 40 lbs.) is only two pounds. And finally, the construction of the desk costs no more than does that of the usual desk with two drawers and a cupboard.

There are teachers of chemistry who feel that mechanical devices for making laboratory work more efficient are beneath their notice. But, after all, the laboratory is essentially a study in which materials take the place of books, and manipulation and thinking take the place of reading and thinking. A book is arranged mechanically for convenient and rapid use, whether it is to be read straight through or employed for reference. Why should not similar attention be given to the mechanical arrangement of the laboratory? Of course, the publisher and printer arrange the book—not the author. But the architect does not know enough about chemical work to devise anything helpful—and we are lucky when he does not knock out part of our plans by

persuading the authorities that they will put the building out of harmony with the other structures on the campus. Hence the chemist must himself tackle the problem in detail. Then again, if the laboratory operations occupy long periods of time, the intervals between the points at which thought by the student is required, or the practise of certain manipulations is demanded, are so prolonged that the pupil forgets to think when the time comes, and bungles the manipulation because his mind has long since wandered to some other subject. Thought and physical activity are more effective when there is a more or less continuous demand for them, and so every abbreviation of the periods of waiting and of the interruptions, caused by looking for some article or going to a hood, increases the efficiency of the work as a form of study. It also, of course, permits more work to be done, and therefore more subjects for thought and more manipulation to be introduced, and so gives more mental training and greater technical skill.

The magnificent addition to this laboratory, the opening of which we are now celebrating, has been made at a most opportune time. A German statistician has discovered that the ratio of chemists to population in four countries is represented by the numbers: Switzerland 300, Germany 250, France 7, Great Britain 6. The corresponding number for the United States is probably nearer to the two last numbers than to the number for Switzerland. The general run of people in this country, even educated and intelligent people, have hitherto been almost entirely unaware of the important rôle which chemistry plays in the industries. When you tell them that many railroads employ fifteen or twenty chemists each, they stare in astonishment, and can not imagine what there is for a chemist to do in such a connection. But the discussion raised by the war has suddenly drawn chemistry out of its modest retirement, placed it in the limelight, and advertised it as nothing else could have done. The number of students in chemistry, always a rapidly growing factor, has this year taken a great leap forward. The University of Illinois is fortunate in having completed a building for chemistry so carefully planned and so magnificently equipped. It is fortunate also in the splendid spirit which has characterized its work in chemistry, and in the remarkable number of investigations of the highest order which have been, and are being carried on in its laboratory. The state of Illinois is to be most heartily congratulated both on the performance of its university, along chemical lines, in the past and, with the space and the facilities which the new laboratory offers, upon its promise of even greater things in the future.

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RESEARCH AS A NATIONAL DUTY

THE object of this paper is to emphasize the importance of material research and to lay stress on its necessity to any people who are ever to become a leading nation or a world power.

I have called it material research because I wanted to exclude immaterial research. I class under this head pure thought as distinct from thought mixed with matter. It is worth while making this distinction because, from the youngest to the oldest chemist, it is not always recognized. It is very natural for us to think we can think new things into being. Chemistry has advanced only in proportion to the handling of chemical substances by some one. When the study of our science was largely mental speculation, and the products and reagents largely immaterial,

like fire and phlogiston, we advanced but slowly. Ages of immaterial research for the philosopher's stone only led to disappointment. Successful results in modern times came from following nature, learning by asking and experimenting, reasoning just enough from one stage of acquired knowledge to ask the next question of materials.

Professor Trowbridge, of Harvard, once said:

> Before Galvani's time men were lost in philosophical speculations in regard to subtile fluids; after his experiments their thoughts were directed to the conditions of matter immediately about them. Benjamin Franklin brought electricity down to earth from the clouds, while Galvini's experiments brought men's minds down from the heights where they were lost, having no tangible transformations to study.

I will go directly to my point. We are being shown by systems of national development how important is the study of the properties of matter. There is no need to raise the questions of the war, nor of the relative originality of different races, nor to compare the gifts to scientific knowledge of the various world powers. We will go only so far as to point out that in national processes there may be a certain peculiar and useful attitude towards exact knowledge. I mean by peculiar that, as is the case of Germany, it differs in direction and intensity from that of other countries. In so far as it is useful, I want to recommend it. We all condemn it where it is abused. I want to convince you, if I can, that in the uses of science we ourselves have much to learn, and in the matter of research we are still children.

In speaking of research, I do not mean to confine my thoughts to the chemists and their knowledge and literature, but rather to that science which is back of chemistry. We may call it natural science, if we are careful. It includes, for my present purposes, all philosophy based on measurable facts. Psychology and therapeutics come under this head; so do electricity and medicine, anatomy and physics, chemistry and biology. These are inquisitive sciences, where the answers come from asking questions of nature. If I can leave with you even a faint impression of the importance of new knowledge, the strength to be gained from its acquirement, and the pleasure in the process itself, I shall feel repaid.

Research is sometimes looked upon as a remote, postponable, and especially exacting undertaking, well suited for martyrs of science and unreasoning optimists, and not at all for teachers. The historical methods of teaching have still lingering in them some of these signs. Even in our day it is sometimes said that a teacher should not be an investigator. It will take a long time to completely efface that idea, but it will be as surely forgotten as the fact that most of our older colleges were once religious centers. It is important to realize that the need, facilities and possibilities of research are all about us, retarded only by the inertia that is in us. So much useful pioneer work in all fields has been done with simple material equipment coupled with good mental equipment, that it almost seems as though this was the rule. The telegraph and telephone started with a few little pieces of wire wound by hand with paper insulation. The basic work on heredity was carried out by an Austrian monk with a few garden peas. The steam-engine came from the kitchen fire, and wireless from the tricks of a little spark gap. There was, however, the same general kind of mind behind each one of these discoveries, the mind of the trained inquirer.

Exactly the opposite belief is also quite

common—that great advances are made by sudden flashes of thought through the mind of some lucky and presumably unoccupied individual. If this were so, there would be little need for the high degree of training which is necessary for almost any scientific service in our day. We may find a simple illustration of this point in organic chemistry. We know that the artificial production of important chemical compounds, such as indigo and rubber, has been accomplished. But how many of us even begin to realize the training that was necessary and the research that had to be done before success could be claimed. The Badische Company spent seventeen years completing the indigo work after the first synthesis, and expended about five million dollars before a pound was put on the market. I might say that without at least fifty years of work by thousands of research chemists, neither problem could have been solved.

I would also be right in saying that if you removed from that structure even a part of the purely theoretical work, such as that where organic chemists spent their lifetimes testing the compounds for the imaginary double bonds of the hypothetical benzol ring, such synthesis would not have been brought about.

In my study I have a photograph of about thirty young research men grouped about Wöhler. This is the chemist of Göttingen who first discovered that an organic compound could be produced in a laboratory. It was he who also made the first metallic aluminum. The picture was taken in 1856, about as early as decent photographs were possible. Every year since 1856 that Göttingen laboratory, among others, has been training chemists in research. They have gone into fields of infinite chemical variety. Each man has been a center in some distant place, and around this center there has often been built up in turn some kind of chemical structure. Many became teachers, and their students in turn became experimenters and teachers. Many followed industrial chemistry and extended the field of the ever-increasing army of chemists. In my particular photograph is one man who in 1866 became the Professor Goessman of the Rensselaer Polytechnic Institute and was later professor at Amherst and very prominent for years in the Massachusetts State Board of Agriculture.

Since 1856 the same seeking for knowledge by renewed groups of such men has been continually going on in many foreign laboratories, but is only slowly being taken up in our country. Is it not time that we awakened to the fact that, as research chemists, we are still in our infancy? If we are ever to be a leading country in industrial chemistry, research is absolutely necessary. If such research is done elsewhere, then the major part of the advantage will lie elsewhere also.

This is one of the most difficult points for an American to recognize. Forests may be leveled by a brawny arm with an ax, canals may be dug with a dredge, but practical science needs knowledge and training, and always more training.

Scientific research, or research in the natural sciences and in the industries, might be defined as the pioneer work of the developed country. In this light it is easy to see that our turn has come. Not long ago our pioneer work was of another kind. It was opening up the undeveloped land. It was actively and well done. But the work must change because our requirements have altered.

Carl Helffereich, director of the Deutsche Bank and now secretary of the treasury of Germany, writing before the war, said:

All economic labor aims at making external nature contribute to the needs of man. It is as true of the primitive gathering of roots and berries as of the production of cyanamid or calcium nitrate. The enormous progress of modern economic technique is due to the splendid development of the natural sciences and the systematic application of scientific knowledge to economic labor. Physics, chemistry and electricity have outvied each other in their influence upon economic technique.

Speaking of the scientists, he says:

Our hermit poets and thinkers converted themselves more and more during the past century into practical creative workers, and an enormous expansion of activity has resulted from the progress of the pure and applied natural sciences.

American chemists have had German chemists pointed to as examples almost long enough, but there is some value in concrete examples, and I can not refrain from comparing our own impoverished condition in the matter of nitrogen to that of Germany.

Excepting one or two minor attempts, we Americans have made almost no study of the fixation of atmospheric nitrogen. I want you to realize the varied and expensive researches, mostly carried on abroad, which were required to reach the present position of the nitrogen question. There were in Germany and, by German capital, in Scandinavia, several direct oxidation processes, carried through the experimental to the practical commercial stage. The Schoenherr process is one of these, the Birkeland and Eyde process another. The direct combination of nitrogen and hydrogen to form ammonia has been successfully developed in the German Haber process, and the cyanamid process, with all its products from carbide to ammonium nitrate, was developed in Germany. There they used not only the peculiar reactions of calcium carbide with nitrogen, but the production of the nitrogen from liquid air, the reaction between water and cyanamid to form ammonia, and then an oxidation process for obtaining the nitric acid. The oxidation of ammonia to nitric acid by such methods as the Ostwald process has been studied by many investigators since 1830, and several different schemes are now in use abroad.

At the time most of this research work was under way it was not at all clear what use was to be made of it. Much of it was purely academic research, but it was clear that without the knowledge itself certainly no use at all would be made of it.

I do not want you to look at research as an old, established utility. I want you to see it as I do: a powerful factor proved in the advance of the industrial welfare of the foremost countries, and a world-experiment of less than a century's trial, but something still unappreciated in America. It is true that the earliest man and many of the lower animals accomplished ends by research, but I refer now to research in the natural sciences and to the research which in our day is necessary to our desired activities. These sciences are already very highly developed, and an equally advanced education is demanded. For example, if I wish to cure physical ills, I can not expect to do it by reciting ancient incantations, nor by using roots and herbs, as was once customary. I must first familiarize myself with an accumulation of previous experience. I must study anatomy, physiology, chemistry, bacteriology, etc. This is a relatively recent world-condition. Conditions are similar in all the applied sciences. The accumulated knowledge in any field is already very considerable, and to get on to the firing-line of useful work one must go up past the baggage-train of knowledge and experience. There is something in the blood which makes an American naturally hate preliminaries. It will be a great day when we see how important

preliminaries are. The hospital surgeon well knows how much more willing the young interne is to actually handle cases, if it is only to administer the ether or the iodine, which any nurse can do, than he is to study the theory of ether as an anesthetic, or of iodine as an antiseptic, which perhaps no nurse could understand. The young student of mechanics thinks he could have devised the steam turbine if it had not been done before his day, but when he comes to study the problem as it has actually been developed, he finds the same old kinetic theories, differentials and integrations which he spurned as too theoretical when he sought a short road to engineering.

I want you to realize that in America we are going ahead in future at a rate dependent entirely upon our preparation. Laboratories are a relatively modern thing. In most of the sciences they are a development within the lives of men now living. I want you to see that we must be foremost in systematic, organized research, or we will be distanced by other countries which already well recognize the value of new knowledge.

When so much of our material welfare, the condition and extent of our manufactures, the quality of our agricultural efforts, and the health of our people, depend upon the rate of our acquirement of new knowledge, there ought to be much greater effort made along the lines of research than is at present the case.

We call knowledge power, but we need to see that new knowledge is like a second power to power.

I'd rather be a little Moses than a big Jeremiah. I'd rather point a way to a promised land, however remote, than talk about our lamentable conditions. But we Americans are not entirely imbued with the spirit of active and efficient service. We are a preliminary experiment on the possibility of operating a competitive nation in a democratic manner, but we don't care much about it. We have about as little interest in the wonder and elasticity of nature, the laws of materials (except where they affect our stomachs and our health) as had Darwin's starving Patagonians. With us the spirit of the hive is confined to the bees. Germans and Japs make better scholars than we do, and a Chinese laundryman sticks longer to his daily job and talks less about it. We are living in the Garden of the Gods, but we are still eating grass.

Is there no significance in the fact that many of our colleges are better known through their foot work than their head work? Is it not significant that the Y. M. C. A.'s dotting our land are as strong in bowling-alleys as in education, and that most of our religious training goes to the heathen? Is it a sign of health that so large a portion of our newspapers are paid to feed us with results of useless experiments between prize-fighters? I think the stadium should be the accessory of the laboratory, not the temple of the oracle; and that in reality a research laboratory is more compatible with the object of a university than is the more common training-table. I do not mean to be too insistent as a critic or too pressing as an advocate, but I hate to see my own country such a trailer as it now is. I hope the conditions are changing, but I know they are not changing fast enough.

All service is based on knowledge, and knowledge is an ever augmenting thing which almost any one may increase. If the stock is *eternally* useful as it is, how great must be the value of the indestructible increments which any one may produce. I do not think due reverence is given to new knowledge. I want to illustrate.

Some time, somewhere, centuries ago, the slag of a fireside appeared transparent,

some one tried to learn more about it, and so, ultimately, glass was made. Research is still under way on that very material, and countless numbers of men have added to the knowledge. Glass has kept the cold from the house. It has let in the light. It has renewed our eyes as they have worn out. Through telescope and microscope it has shown us the greatest and the smallest things of the universe. It has bottled our drinks and held our lights. Every year still adds new service, just in proportion as experiments add new knowledge of glass. To-day we hear of new glass permeable to ultra-violet light, glass opaque to X-rays, and glass for cooking utensils. Not one of these little increments will ever be lost, but will continue in use, so how highly should we value them? Why did we delay so long in coming thus far, and how far or fast may we still go?

Research is preparation. It is preparing in our decade for the problems and the necessary work of the next. There are various kind of preparedness. We are hearing a great deal about one of them nowadays—immediate preparedness for national defense. But there is a more far-sighted preparedness that no one has adequately described and of which the building of new laboratories is a sign. This type is the very best kind of preparedness for national defense, if begun in time. The continued study of the secrets of nature, the uncovering of buried treasures which always seem buried just deeply enough to develop the digger—these are the criteria of a strengthening nation.

Research presents a way, and the only certain one, of insuring peace, of preparing successfully for defense, and of being successful in war. It is the lasting, undeviating factor which has always dominated. This may sound bold and entirely inconsistent in itself. It is all true. Can we learn to see it? From the military expert to the anthropologist, thinking men recognize that for over 100,000 years war has been almost continuous on the earth. The inventors of chipped flint successfully fought those inferiors who had not experimented with flint. There were then no better arms. These also got their game even when it was scarce and other means failed, and so they continued to survive. This little and early example of survival was repeated a great many times before our present complex world conditions were reached, and will as surely continue to be repeated. The fundamentals were always the same. A 42 cm. gun is only a better flint. Trinitrotoluol is only a more modern sling. Arms and ammunition have changed, but just so have also changed the myriads of other important accessories to survival. This is the important point. Good guns go with good clothes, and niter is used both in fertilizers and in guncotton. The signs that we are improving in our civilization will also indicate that we are growing in our powers of national defense, but this should come rather as a consequence than as an object. And we Americans must not stand still. The world has always been improving, and the real growth and development has come to those nations which have been responsible for the original research work and not for the mere storage or conservation of the knowledge.

The first or fundamental discovery in any series is not the only important one, so I am going to take an extreme view and say it is only the continuation of research which is of any considerable importance to us. The fundamental discoveries may be like seeds, but the values are like growing plants. An acorn may correspond to the work of a Henry or a Faraday, but the great and growing tree of electrical or chemical work corresponds more nearly to

the living state of the oak species. We are much more interested in what is to come than in what has already been accomplished.

I realize that I ought to illustrate this appeal for research by concrete examples of things to discover. I know the feeling of the chemist who is mentally compressed by the mass of investigation work which has already been done and by the known facts which seem already to entirely cover all possibilities; but I know, too, that the future will make use of knowledge for which we now have no vocabulary and no powers for comprehension, and so could not possibly anticipate. If, then, I try to illustrate the search for new knowledge, you may be sure my illustrations will be inadequate.

In the first place, I can not be reckless enough. This I learn from looking backward. I would not have dared suggest that a dozen good men should study the little hydrogen generator of the freshman laboratory, to see what was in it. If I had, I suppose I should have suggested a research on pipe organs, because of the singing hydrogen flame, or on bombs, because of its explosion. But some one tried synthetic ammonia, others Zeppelins, and others the cutting and welding of iron. When I see in our factory the three score men now using oxhydrogen all day for this latter use, I am impressed with the eternal proximity of new and useful knowledge. A very few years ago, two or three times as many men would have been necessary to do this work in the old more difficult and less satisfactory manner.

The most natural suggestions for research are those simple ones referring to chemical elements. There are still plenty of unknowns among the elements, and of one thing we may be sure, there are certainly no two alike. Any chemist who wants to add to chemical knowledge need not go beyond the list of elements for his subject. The properties he discloses will every one of them be sometime a help to his science and of service to his country. As far as possible, his country will reward him with patents if he asks them.

We ought to begin at the points where others left off, and continue the research of the chemical elements. One reason why this appeals to me is that I have seen so many recent applications of entirely new knowledge of elements in my own work. I will just mention tungsten, molybdenum, boron, argon, silicon, magnesium, titanium, thallium, vanadium and chromium, which, because of properties not known until recently, are nevertheless already doing commercial service in our restricted electrical field. Surely we know still far too little about these elements, but we know less about some others.

If now the chemist, still forgetting the compounds and narrowed in his researches to the elements, and then perhaps to the metals, and finally to a single element, still asks, what shall I do? I would refer him to the isotopes of his element. Our American Richards, supporting the researches resulting from the studies of radioactivity, has shown that there are two leads. They are somewhat different, but can not be separated easily. Of course some one ought to separate all isotopes, and then there is plenty of room for research on the single isotope.

One of the great needs of the country which reflects on us chemists and calls for immediate research is that for American potash. There is no supply in sight which is nearly comparable with the German deposits, and our fertilizer and other industries will certainly suffer because of this deficiency. We have plenty of feldspar calling for a simple process for removing

the potash it contains. We have oceans of sea water carrying plenty of potash, if we knew how to extract it. Don't say it can't be done, for it is already done by miles of seaweed. Why should we confine ourselves to trying to take it away from the seaweed, instead of learning what the seaweed knows about getting it from the water? You will look supercilious, but until a large number of chemists have studied semipermeable membranes, there will always be this lack of understanding of those simple reactions of living matter going on around us. There will always seem to me a possibility of doing such physical and chemical processes more nearly as we may wish to do them when we know how these operate.

When nothing new is being done by us it will be a sure token of our decay. When we stop increasing our experimental activities or fall for a considerable time behind the activities of other countries, we may expect to see our light become merely a memory, like that of Greece or Rome. Thus far we Americans have not reached a fair average as investigators in natural sciences, and yet we have incomparably superior conditions for the growth of research. I can not look beyond the period when research shall cease in a country and still imagine that country a power in the world.

There are no sharp lines to be drawn through research to separate pure from applied, scientific from practical, useful from useless. If one attempts to divide past research in such a manner, he finds that time entirely rubs out his lines of demarcation. At this particular time, however, one may imagine a more or less zigzag zone which serves to divide research in a commonly accepted way.

In a manufactory the price of a new product should include the cost of research. No matter how complicated the system, this is always true. Otherwise the industry would ultimately commit suicide. In practise it is common to apportion to particular products the cost of their separate development, and to fix the price so that within a reasonable time, or by a reasonable volume of sales, the so-called development cost may be wiped out. Thereafter the product may be sold on the basis of the continuing cost of actual production. While this system is extensive, it does not cover the cost of many of those original researches which may have been absolutely necessary. The argon tungsten lamp, in its development cost, did not carry the expenses of Rayleigh and Ramsay's work, and so there will probably always be some such classification of research work necessary.

Under such a classification, the part of research I am most interested in promoting is what we may call the unpaid kind, not because it is cheapest, but because it is the most valuable. It is most neglected, most poorly understood, most in need of appreciative support in America.

The separate industries do not need encouragement in research nearly so much as the nation needs it. The industries can be depended on to estimate its value to them, for they take annual inventories. But a country which keeps no books seems to have to depend on instinct and environment for its most valuable research work.

It seems to me that our American colleges have been shortsighted in this respect. This may be explained by the rapidly increasing demand in our growing industries for analytical chemists and chemical engineers, who could at once meet the existing industrial requirements. This demand has kept the chemical departments of our colleges and technical schools very busy with the elementary and analytical side of chemistry and left little room for the synthetical or experimental side. It has also naturally tended toward the development of highly

efficient organizations, equipments and corps of instructors for the preparation of the one type of chemist, but this very success seems frequently to make impracticable the training of men for research. The conscientious American professor has usually devoted his life to bringing his students up to a certain promising stage of interest in science and experiment, only to see them scatter before they have had any experience with questioning nature, or have tried any unbeaten chemical byway.

While I am greatly interested in what might be done for science by technical research laboratories in the industries, I am sure that the university must be the important factor in guiding the pioneer work if we are to be a sufficiently advancing nation.

Let me recall recent words of President Wilson:

> I know I reflect your feeling and the feeling of all our citizens when I say the only thing I am afraid of is not being ready to perform our duty. I am afraid of the danger of shame. I am afraid of the danger of inadequacy. I am afraid of the danger of not being able to express the correct character of the country with tremendous might and effectiveness whenever we are called upon to act in the field of the world's affairs.

These words ring true. The American spirit is characterized by them. But think further a moment. They refer to a fear based upon an entirely corrigible defect. The cure is in our hands. The time when we are called upon to act in the field of the world's affairs is *now*; but it was yesterday, and it will be to-morrow. I maintain that no nation can effectively act in that field at odd or selected moments. It is either doing it much of the time, or it is likely to be unable to do it any of the time.

WILLIS R. WHITNEY

GENERAL ELECTRIC COMPANY,
SCHENECTADY, N. Y.

THE COMMITTEE ON POLICY OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE Committee on the Policy of the American Association for the Advancement of Science met on April 17, 1916, in Washington. Messrs. E. L. Nichols, *chairman;* Charles R. Van Hise, *president;* R. S. Woodward, *treasurer,* J. McK. Cattell, W. J. Humphreys, A. A. Noyes, Stewart Paton, E. C. Pickering and L. O. Howard, *permanent secretary,* were present.

The committee on delegates to the meetings was instructed to make an especial effort to secure delegates from the educational and other scientific institutions to the New York meeting, as this will be the first of the large four-year meetings.

The treasurer and the permanent secretary presented financial reports which were ordered printed in SCIENCE.

The committee on new affiliated societies reported that the following societies had been admitted to affiliation: American Genetic Association, Eugenics Research Association, Illuminating Engineering Society, Wilson Ornithological Club, and the Mid-West Forestry Association. The American Institute of Chemical Engineers and the American Society of Heating and Ventilating Engineers were invited to become affiliated.

The treasurer reported with regard to the Colburn bequest and stated that approximately seventy-eight thousand dollars ($78,000) in cash and bonds had been turned over to him by the executors. On motion, the treasurer was authorized to convert cash to the amount of eighty thousand dollars ($80,000) into securities approved by the state laws of New York and Massachusetts for savings banks and trust funds. On motion, it was directed that these investments be made with the advice of a committee of three, of which the treasurer and Mr. A. S. Frissell shall be members, they to select the third member.

The permanent secretary announced the death of Professor Thomas J. Burrill, the chairman of Section G, stating that he had sent, in the name of the committee, a tele-

gram of condolence to the president of the University of Illinois. On motion, such nomination as the sectional committee of Section G may make to fill the vacancy caused by this death shall be final.

A discussion followed with regard to the arrangements for the New York meeting. It was moved and carried that a committee consisting of Messrs. Charles Baskerville, N. L. Britton, J. McK. Cattell, Simon Flexner, M. I. Pupin, Henry F. Osborn, J. J. Stevenson and Edmund B. Wilson, be appointed an executive committee to make the New York arrangements.

The report of the committee on the administration of the Colburn will fund was submitted by Professor Pickering. On motion, it was moved to refer the report back to the committee for revision to include the administration of all research funds of the association, to add Messrs. A. A. Noyes and W. B. Cannon to the committee, and to make a final report to the committee on policy at its next meeting in November. It was suggested further that it might be well to refer the first draft of the report by mail to the members of the committee on policy.

At 10.25 P.M., the committee adjourned.

SCIENTIFIC NOTES AND NEWS

Hilgard Hall has been selected as the name for the new agricultural building being built by the University of California, in honor of the late Eugene Woldemar Hilgard, for a generation professor of agriculture and dean of the college of agriculture of the University of California.

At the meeting of the Franklin Institute, Philadelphia, on May 17, Franklin medals will be presented to Professor Theodore William Richards, director of the Wolcott Gibbs Memorial Laboratory, Harvard University, and to John J. Carty, chief engineer of the American Telephone and Telegraph Company. The Elliott Cresson medal will be presented to the American Telephone and Telegraph Company, Theodore N. Vail, president. Addresses will be made by Professor Richards on "The Fundamental Properties of the Elements," by Mr. Carty on "The Telephone Art" and by Mr. Vail.

H. H. Stoek, professor of mining engineering in the University of Illinois, has been appointed by Governor Dunne, of Illinois, as a member of the commission authorized to consider legislation concerning mines.

The Mary Putnam Jacobi Memorial Fellowship has been awarded to Dr. Mildred Clark, Johns Hopkins, 1914, who will use the fellowship for research work in medical bacteriology with Dr. Theodore C. Janeway at the Johns Hopkins Hospital.

Dr. Alvin Powell has been appointed physician for men and roentgenologist in the infirmary of the University of California.

The position of horticulturist to the Missouri Botanical Garden has been filled by the appointment of Mr. Alexander Lurie. Mr. Lurie is a graduate of Cornell University, and has been in charge of greenhouses and instructor in floriculture, in the University of Maine.

Professor A. L. Kroeber, head of the department of anthropology in the University of California, is spending the present academic year in New York City as a guest of the American Museum of Natural History.

Because of ill health, Professor A. Fraenkel retired from the directorship of the Krankenhaus am Urban in Berlin, on April 1. He is succeeded by Professor A. Plehn, who has been the physician in chief of the medical division for the past thirteen years. Most of his time has been devoted to the study of tropical diseases and diseases of the blood.

Dr. William Palmer Lucas, professor of pediatrics, University of California, has gone to Belgium for relief work in connection with the infants' and children's dietetic problems which have arisen there.

Mr. Shoitsu Hotta, assistant professor of forestry at the Tokyo Imperial University, has entered the Yale School of Forestry. Mr. Hotta will be in the United States for a period of two years.

ACCORDING to the *Nieuwe Courant,* as quoted in *Nature,* the Royal Academy of Sciences of Amsterdam has awarded the following grants from the Van't Hoff Research Fund: $125 to Professor F. Ephraim, of Berne, for the continuation of his studies on the nature of subsidiary valencies; $250 to Dr. P. E. Verkade, of Delft, for the purchase of apparatus for the determination of heats of combustion; $50 to Dr. D. H. Wester, of The Hague, for a chemical examination of certain species of Loranthus; $100 to Dr. C. H. Sluiter, of Vught, for the purchase of Beilstein's handbook and of materials for an investigation of formaldoxime; $100 to Professor E. Jänecke, of Hannover, for the continuation of his work on melting and transition points under high pressures.

AT the sixty-ninth annual meeting of the Paleontographical Society, London, on March 31, Dr. Henry Woodward was reelected president; Dr. G. J. Hinde was elected a new vice-president; Mr. R. S. Herries was reelected treasurer; Dr. A. Smith Woodward was reelected secretary, and Miss Mary S. Johnston, Mr. H. L. Hawkins and Mr. G. W. Young were elected members of council.

PROFESSOR HENRY S. WHITE asks us to state that the footnote on page 591 of the last issue of SCIENCE should have referred to the presidential address of Professor E. B. Van Vleck on "The Rôle of the Point-set Theory in Geometry and Dynamics," *Bulletin of the American Mathematical Society,* Vol. 21 (1915), pp. 321–341.

THE Cutter Lecture on Preventive Medicine and Hygiene was given by Dr. Simon Flexner, director of the Laboratories, Rockefeller Institute for Medical Research, on "The Finer Adjustments of the Immunity Reactions to Recovery from Infection," at the Harvard Medical School on April 26.

THE eleventh Harvey Society Lecture was delivered at the New York Academy of Medicine, on April 29, by Dr. William H. Welch, of the Johns Hopkins University, on "Medical Education in the United States."

LAFAYETTE B. MENDEL, professor of physical chemistry in Sheffield Scientific School, Yale University, will deliver an address on "Abnormalities of Growth" before the experimental medicine section of the Cleveland Academy of Medicine, May 12.

PROFESSOR WALTER B. CANNON, of the Harvard Medical School, gave a lecture before the section on general medicine of the College of Physicians of Philadelphia at Thompson Hall, on April 20, on "An Explanation of some Disorders supposed to have an Emotional Origin."

DR. JAMES WILLIAM WHITE, emeritus professor of surgery in the University of Pennsylvania, and a trustee of the university, died on April 24, aged sixty-six years.

PROFESSOR HOWARD DRYSDALE HESS, of the department of machine design, Sibley College, Cornell University, died on April 22, aged forty-four years.

PROFESSOR HENRY BARBER NIXON, Ph.D., since 1888 in charge of the department of mathematics in Pennsylvania College, Gettysburg, Pa., died on March 30, at his home on the campus.

CHARLES ALBERT DAVIS, peat expert in the U. S. Bureau of Mines, known for his investigations on peat and related subjects, died in Washington on April 9, aged fifty-five years.

CHARLES ALBERT CATLIN for nearly fifty years chemist for the Rumford Chemical Works, known for his work on phosphoric acid and its compounds, died at his home in Providence, R. I., on April 13, aged sixty-seven years.

GEORGE EDWARD PATRICK, chief of the dairy laboratory in the bureau of chemistry of the Department of Agriculture, died in Washington, on March 25.

DR. EDGAR MOORE SENSENEY, professor of diseases of the nose, throat and chest in Washington University, died in St. Louis, on April 7, aged sixty years.

DR. WILLIAM FREDERICK KING, chief astronomer of the Canadian government, superin-

tendent of the Geodetic Survey of Canada, and director of the Dominion astronomical observatory, died on April 23, at the age of sixty-two years.

Professor F. Schenck, the director of the physiological institute at Marburg, has died, aged fifty-three years.

Dr. P. Chappuis-Sarasin, the Swiss physicist, has died at Basel at the age of sixty-one years.

The cornerstone of the laboratory building of the Brooklyn Botanic Garden was laid, with brief formalities, on Thursday afternoon, April 22, 1916. Plans and specifications have been approved for a children's garden building to be erected this spring at a cost of $6,550. A large rock garden is also being completed this month, and four additional wings of the plant houses are under construction.

The authorities of the University of Alabama and of the Bryce Insane Hospital, have joined in making the lands of the two institutions, with an area of approximately 1,200 acres, into a bird sanctuary, and at the same time members of the faculty of the University of Alabama have been instrumental in the formation of a bird club, to be known as the Tuscaloosa Bird Club.

Mr. Ogden Mills, of New York, has agreed to provide a gift of $8,250 this year and $8,250 during the next academic year for the maintenance of the D. O. Mills Expedition from the Lick Observatory of the University of California to the southern hemisphere, the expedition making its headquarters at Santiago, Chile.

The eighth semi-annual meeting of the American Institute of Chemical Engineers will be held in Cleveland, O., from June 14 to 17.

A new scientific association has been formed at the University of Alabama with William F. Prouty, professor of geology, as president. The members of the association are restricted to the scientific men of the faculty. The purpose of the association is chiefly to stimulate scientific research, and to provide means for the review of highly specialized publications dealing with subjects on the border-line of the different sciences.

The Chemists' Club of New York announces the establishment of a scholarship fund, the income from which, approximately $500 per year, is to be devoted to assisting financially deserving young men to obtain education in the field of industrial chemistry or chemical engineering. This scholarship has been endowed by Dr. Victor G. Bloede, a prominent manufacturing chemist of Baltimore. Its benefits will be open to properly qualified applicants without restriction as to residence, and may be effective at any institution in the United States which may be designated or approved by the Chemists' Club. Applicants must, as a minimum qualification, have completed a satisfactory high-school training involving substantial work in elementary chemistry, physics and mathematics and present a certificate showing that they have passed the entrance examination requirements of the college entrance examination board or its equivalent. Preference will be given to young men who have supplemented these minimum qualifications with additional academic work, especially in subjects which will form a suitable ground work for the more advanced study of applied chemistry and chemical engineering. All inquiries should be addressed to the Bloede Scholarship Committee of the Chemists' Club, 50 East 41st Street, New York City. Applications for the academic year 1916–17 should be in the hands of the committee on or before June 1, 1916. The scholarship will be awarded and candidates selected and notified on or before July 1, 1916.

UNIVERSITY AND EDUCATIONAL NEWS

The University of California regents have adopted a budget for 1916–17 which contemplates the expenditure of $2,565,975. The principal change as compared with the budget of the previous year is an outright addition of $70,000 from its general fund to the university's annual provision for the maintenance of

the University of California medical school. For the year ending June 30, 1917, the University of California will expend $321,200 on its medical work, the principal items being as follows: salaries, $87,450; budgets, $49,750; for the maintenance of the University of California Hospital (the new 216-bed teaching hospital, under the complete ownership and management of the university), $134,000, of which $35,000 will come from receipts from patients and the balance from the income on endowment and from the general fund of the university; for the maintenance of the George Williams Hooper Foundation for Medical Research, $50,000.

A new separate department of biochemistry and pharmacology has been established in the University of California Medical School. It will be headed by Dr. T. Brailsford Robertson as professor of biochemistry.

Percy R. Carpenter, of Amherst College, has resigned his position as associate professor of hygiene and physical education to accept the post of professor in the Worcester Polytechnic Institute.

William J. Robbins, Ph.D. (Cornell, '15), has been appointed professor of botany in the Alabama Polytechnic Institute, Auburn, Ala.

Dr. H. L. Hollingworth has been promoted to be associate professor of psychology in Barnard College, Columbia University.

The executive committee of the City and Guilds of London Institute has appointed Professor G. T. Morgan, F.R.S., of the Royal College of Science, Dublin, to the chair of chemistry at the Institute's Technical College, Finsbury, vacant by the death of Professor Meldola.

DISCUSSION AND CORRESPONDENCE

PUBLIC HEALTH WORK

To the Editor of Science: I have previously[1] called attention to what, for a lack for a better designation, may be termed a type of medical fallacy in public health. In Dr. C. R. Bardeen's article, "Aims, Methods and Results in Medical Education," there again appears in your columns another type of medical fallacy in public health. On page 377 of your issue of March 17, he states:

> No sharp line can be drawn between preventive medicine, on the one hand, and curative medicine, on the other hand. Public health officers can not do thoroughly effective work if they can not apply remedies to diseased individuals as well as to other sources of danger to the public health. By far the most effective public service in this country to-day is the United States Public Health Service and here treatment of individuals and treatment of environment are carried on hand in hand.

These sentences define a fallacy which is the outgrowth of medical training and viewpoint, in which emphasis is placed on treatment and not on prevention. Medical education is a training to enable a man to derive an income through the practise of a profession. In our present organization of society, the members of the medical profession obtain their income by the cure of diseases that exist, and do not receive compensation for disease which is prevented. The matter having a financial basis, the emphasis must be placed on cure, not on prevention.

He speaks of "treatment of individuals and treatment of environment" in the same breath, as if they are, or could be, in any way similar. Apparently the vast differences in personal rights and property rights before the law are completely ignored.

With reference to his first sentence, a line of demarcation can, and must be, drawn between preventive medicine and curative medicine in public health work. Under our form of government, it is not possible for public health officers to apply by compulsion remedies to diseased citizens. Such would be totally repugnant to our institutions and our ideals of government.

Dr. Bardeen states that in the United States Public Health Service "treatment of individuals and treatment of environment are carried on hand in hand." A high-school boy would at once recognize this as an error of statement. The constitution, neither directly nor by implication, gives to the federal government, or to any of its bureaus or depart-

[1] Science, August 20, 1915, p. 243.

ments, the right to apply medical treatment to individuals. The functions of the Public Health Service are limited to interstate or foreign regulation, except in such cases where the state itself invites and authorizes the Public Health Service to perform specific functions within its territory. Neither may treatment, if it may be called such, be applied to environment or property except by due process of law, in such a manner as to duly conserve property rights.

Fallacies of this type are due to the fact that, while the medical profession is much engaged in public health work because its members have in the past come nearest to having the qualifications necessary for such work, physicians are apparently too greatly limited in their understanding of government to realize that, while public health has medical aspects of the greatest importance, nevertheless public health is a function of community life, founded upon law and our form of government. Until such time as all people will learn that the ideals of a single profession, no matter how excellent, can not be applied to people in the mass, except as such ideals are founded on the law, and are in strict accord with fundamental rights of individuals and well-defined principles of government, we may expect to find fallacies such as this continually appearing.

Harold F. Gray

THE CENTIGRADE THERMOMETER

"No man that has any regard for his reputation will care to say that the irrational, inconvenient Fahrenheit scale ought to be maintained," is the modest and diplomatic way in which Representative Johnson, editor of a country newspaper, passes judgment on some two hundred millions of people who never knew it. As for being irrational, any heat scale is arbitrary; if inconvenient, it could never have been generally accepted. Nine tenths, probably, of the use of a thermometer is for the weather; and practically the F. degree is a convenient one, while the C. degree, being about twice as coarse, would involve fractions. Some people perhaps think that a centigrade scale has something to do with grams and liters; but I never could see any special convenience in 15.°5 C. as a temperature reading in density determinations. A scale is convenient if you find it so; it is rational if its divisions are such that the quantities commonly used can be expressed in units.

In all English-speaking countries all technical and manufacturing work uses the F. scale; and all the common people are familiar with it. Unless there is some reason for change it should be let alone. The fact that I and a few hundred other people in this country are familiar with the thermometer used in France and Germany is no adequate reason why a hundred millions of our fellow-citizens should be put to a great inconvenience which will never benefit them or their descendants in the least. Perhaps a rose by any other name would smell as sweet; but why not keep on calling it a rose?

A. H. Sabin

Flushing, N. Y.,
March 11, 1916

SCIENTIFIC BOOKS

Transactions of the International Union for Cooperation in Solar Research. Vol. IV. (Fifth Conference), Manchester, At the University Press. 1914. Price $3.25 net.

This tri-lingual volume (English, French, German), representing the high water mark of friendly cooperation in scientific research, comes as an almost painful reminder of conditions shattered by war, of friendships replaced by enmity, of constructive science replaced by destructive art.

The Solar Union, not quite adequately described by its title, was organized, largely under American auspices, as a common meeting ground for the most distinguished students of astrophysics throughout the world. From the beginning its cosmopolitan character has been served through holding stated meetings in divers lands. The present volume contains an account of the fifth of these meetings, which was held at Bonn in the summer of 1913. In addition to reports upon the progress of mat-

ters formally undertaken by the Union at former meetings, we find a considerable number of accounts of investigations privately conducted and submitted to the Union as coming within its general province, the whole composing a *pot pourri* probably beyond the competence of any one person not a professed encyclopedist. Among the matters discussed we note, by way of illustration only, the sun's rotation; the measurement of its radiant energy; the measurement of wave-lengths; observation of sun spots, prominences and faculæ; the organization of solar eclipse observations; the study of solar vortices; the refraction of light in the solar atmosphere; the sun's magnetic field; etc.

While in general the papers dealing with these several themes can hardly be regarded as addressed to the lay reader, when taken in connection with the discussions evoked, they furnish to the serious student the best available résumé of current opinion upon controverted questions relating to the sun, as well as upon certain wider aspects of general physics. The reporting appears to have been well done, although, perchance, something of geographic prophecy rather than current fact is to be found in the secretary's classification of Finland as an independent country and the assignment of Kopenhagen to Norway, in the tabular list of delegates.

The personal reports of American participants in the conference confirm the impression produced by the narrative parts of the volume, that the hosts left nothing undone that could promote the social side of the conference and the enjoyment of their guests. How bitter must be to many of these the commentary of August, 1914, upon the chairman's closing words in August, 1913, "und so hoffe er dass die Bonner Versammlung nützbringend für die Wissenschaft und angenehm für die Theilnehmer werden würde, so dass sie später gern an Bonn zurückdenken könnten."

While it is not to be supposed that the present European war will end international coöperation for scientific research it has certainly placed obstacles in the way thereto, and may it not be that in the coming decade men of divers tongues, accustomed to work together for the advancement of knowledge, may find a major line of usefulness in collectively seeking to restore good will to the world.

GEO. C. COMSTOCK

UNIVERSITY OF WISCONSIN

Representative Procedures in Quantitative Chemical Analysis. By FRANK AUSTIN GOOCH, Professor of Chemistry and Director of the Kent Chemical Laboratory in Yale University. New York and London: John Wiley & Sons, Inc. 1916. Pp. viii + 250. Price $2.00 net.

In the volume entitled "Methods in Chemical Analysis" published in 1912, the author gave to his colleagues a fund of material drawn from the records of a laboratory which for more than a generation has outranked most others in the development of authoritative analytical procedures. In the volume under review he writes from the fullness of his experience as a teacher of quantitative chemical analysis, one whose influence has been widely felt, through both his publications and his pupils. The manual is intended as an introduction to representative analytical procedures.

The book opens with a brief discussion of non-reversible and reversible reactions, including the mass law and the principle of LeChatelier. This is succeeded by a full consideration of the processes of weighing and measuring. The analytical procedures are, as usual, subdivided into gravimetric and volumetric analyses, the latter including brief sections upon gasometric and colorimetric methods. The concluding chapter deals with systematic analyses of brass, limestone, silicates, substances yielding ammonia, and a few applications of indirect methods of analysis. Among the volumetric procedures much space is devoted to iodometric processes, many of which have been devised or developed in the Kent Laboratory. Iodometric processes are, as the author states, among the most accurate and satisfactory available, and do not, in general, receive the recognition which they deserve.

While detailed directions for "experimental processes" (that is, analyses to be performed) are numerous, the usefulness of the manual is by no means limited to these, since the range of processes discussed in the text is exceedingly wide. The richness of the author's experience is reflected in many unusual suggestions as to technique and reagents, such, for example, as the employment of anthracene filters, and the use of sodium tungstate as an absorbent. The treatment of such topics as the variations in solubility of precipitated substances under varying conditions, colloids, the washing of precipitates, electrolysis, normal solutions and indicators is broad and scientific, and should give the thoughtful student a clear notion that analytical chemistry is not only much more than a question of manual skill, but something demanding his best intellectual efforts. In a few instances, notably the basic acetate process, the explanation of the part played by the various reagents might to advantage be somewhat elaborated.

The book is a noteworthy and valuable addition to the literature of analytical chemistry. It contains much that is of novel interest to a more experienced analyst, but it is probable that many teachers will question whether a beginner, lacking a background of experience, will be able to appreciate and use the descriptive material which is included in the text, but not directly applied to definite analyses. This material is, however, so arranged as to permit of selection, and it is all stimulating to the interested worker.

H. P. Talbot

The Embryology of the Honey Bee. By James Allen Nelson, Ph.D. Princeton University Press, Princeton, N. J., 1915.

A monograph of 282 pages with 95 figures in the text and six plates is an achievement in itself even when one deals with a comparatively well-known subject; but the present monograph is not simply a compilation. Dr. Nelson has incorporated in this work a great deal of his own research and many original observations. His account of the work done by others is accurate and, while preserving his own point of view, he displays in his criticism the admirable quality of abstaining from personal remarks which so often mar the pages of scientific papers.

It would be very difficult to review the whole book in detail since many chapters naturally deal with facts already known to science, which merely find their confirmation here. I shall therefore endeavor only to emphasize some of the observations new to science and to point out certain shortcomings in this otherwise excellent book. Thus, in the chapter on cleavage, Nelson makes the interesting statement that "the size of the nuclei is, in a given egg, quite uniform from the beginning to the end of the period under consideration, *but varies considerably in different eggs*, ranging from 9–14 microns" (p. 21) (italics are mine). In every other respect Nelson's observations on cleavage are in harmony with those of other investigators. The figures accompanying this chapter are fairly good, but the addition of a figure representing a sagittal section through an egg at the end of the cleavage process would have been advisable. The chapter on the formation of the rudiments of the mid-intestine is accompanied by excellent figures and gives new support to the opinion expressed by the reviewer and others that the mesenteron is derived from the mesoderm, although Nelson believes that a choice is possible between this interpretation and that of *Carrière*, according to which the mesenteron rudiments may be considered to be purely blastodermal in origin, such a choice depending "largely on the theoretical bias of the interpreter." In the next chapter Nelson comes to the conclusion that both the "Rz" cells described by the reviewer and the "yolk plug" are identical with the "cephalo-dorsal body." This affords the reviewer an opportunity to state that he, too, is now of the same opinion. That the reviewer has never before come out with a statement to this effect, is due to the unusually personal note struck by his critics, even to an insinuation of motives other than a desire to find out the truth. In such cases silence seems always to be the best answer. With the fall of the interpretation

of the "Rz" cells as derivatives of the fused polar bodies and with the new light thrown on the spermatogenesis of the honey bee, the reviewer has been fully, if tacitly, converted to the interpretation of the origin of the sex-glands from the visceral wall of the mesodermal tubes as promulgated by Wheeler and Heymons and accepted by Nelson. Of especial interest are the chapters on segmentation and nervous system. It is rather unfortunate that instead of giving a diagram of his own, representing segmentation in insects, Nelson reproduces in Fig. 36 a diagram from Snodgrass, which can not be considered correct. Nelson himself is aware of this, as may be seen from his footnote on page 106. It is important to mention that Nelson describes and figures the evanescent appendages of the tritocerebral or intercalary segment in *in toto* views of the egg (VIII*a*, 3Br). Although the truth of his statement can not be doubted, this as well as the following figures are not conclusive and we regret that no figure is given of a transverse section through the region of the tritocerebrum as described on page 106. Another point of interest is the absence of a segment between the mandibles and the maxillæ as described by Folsom for *Anurida.* The reviewer has never been able to accept Folsom's interpretation and finds in Nelson's description a new proof against the existence of such a segment. On the other hand, the rudiments of the second maxillæ (the future lower lip) in the honey bee appear well represented in Figs. X.–XIII. The rudimentary appendages representing the future thoracic legs disappear before the larva is hatched. The statement that the abdomen consists of 12 segments must be accepted as correct, but a drawing of the sagittal section showing all segments is wanting. A feature of great importance, especially for future investigators, is the table showing the rate of development. The data accumulated by Nelson for this are much more correct and detailed than those obtained by any of his predecessors. The drawings are well executed and for the most part original. Some of them are especially welcome, as for instance Figs. 1 and 2 showing the external structure of the egg, Fig. 39 showing the cephalic portion of the nervous system of a newly hatched larva, Figs. 63 and 64 showing the tracheal system and the figures reproduced in the plates.

Many readers will probably regret that no account is given of oogenesis, of spermatogenesis or of fertilization. To be sure, the inclusion of these chapters would have increased the size of the book as well as required careful sifting of data and a great deal of original, tedious reinvestigation. At the same time it would be difficult to find a more appropriate place for these chapters than in a monograph on embryology. But it is scarcely fair to criticize the author for omitting to deal with a subject which does not necessarily come within the scope of his work. Dr. Nelson's is the first comprehensive monograph which has ever been printed on the embryology of the honey bee. It will be of great value both to the investigator and the student and we should be truly grateful to its author for having presented us with a work of such high standard.

Alexander Petrunkevitch

SCIENTIFIC JOURNALS AND ARTICLES

The March number (Vol. 22, No. 6) of the *Bulletin of the American Mathematical Society* contains: Report of the twenty-second annual meeting of the society, by F. N. Cole; Report of the winter meeting of the society at Columbus, by H. E. Slaught; "On Pierpont's definition of integrals," by M. Fréchet; "Reply to Professor Fréchet's article," by J. Pierpont; Review of Carmichael's Theory of Numbers and Diophantine Analysis, by L. E. Dickson; "Notes"; and "New Publications."

The April number of the *Bulletin* contains: "Some remarks on the historical development and the future prospects of the differential geometry of plane curves," by E. J. Wilczynski; "A certain system of linear partial differential equations," by H. Bateman; "Changing surface to volume integrals," by E. B. Wilson; "A new method of finding the equation of a rational plane curve from its parametric equations," by J. E. Rowe; "The physicist J. B. Porta as a geometer," by G.

Loria; Review of Pierpont's Functions of a Complex Variable, by H. P. Manning; "Shorter Notices": Snyder and Sisam's Analytic Geometry of Space, by R. M. Winger; Slichter's Elementary Mathematical Analysis, by L. C. Karpinski; Ford's Automorphic Functions, by A. Emch; Gibb's Interpolation and Numerical Integration and Carse and Shearer's Fourier's Analysis and Periodogram Analysis, by M. Bôcher; Herglotz's Analytische Fortsetzung des Potentials ins Innere der anziehenden Massen, by W. R. Longley; Lange's Das Schachspiel, by L. C. Karpinski; Ince's Descriptive Geometry and Photogrammetry, by V. Snyder; "Notes"; and "New Publications."

SPECIAL ARTICLES

THE PRESSURE OF SOUND WAVES

In his "Wärmestrahlung"[1] Planck, after proving from electromagnetic theory that the pressure of radiation equals the volume density of radiant energy, shows that the corpuscular theory of light would give a pressure twice as great. From this he infers that the Maxwell radiation pressure can not be deduced from energy considerations, but is peculiar to the electromagnetic theory and is a confirmation of that theory. The implied conclusion is that mechanical waves would not exert a pressure of this magnitude. It may be well to recall, therefore, that Lord Rayleigh has shown, from energy consideration,[2] that transverse waves in a cord exert a pressure equal to the linear energy density, and that sound waves in air must cause a pressure equal to the volume density of energy in the vibrating medium. Altberg[3] has made the conclusions of Rayleigh the basis of a method of determining the intensity of sounds.

As the pressure due to sound waves in a gas must be ultimately the result of molecular impacts, it would seem probable that the magnitude of this pressure may be determined from the elementary kinetic theory, and this proves to be the case. Consider an extended wave incident normally on a unit surface. According to the kinetic theory, the molecules which strike this surface are reflected with the same velocity that they had just before impact. As the surface is small in comparison with the extent of the wave front, we need not follow the history of these reflected molecules, which will immediately become dispersed in the passing wave in all directions. In other words, under these conditions no stationary waves will be formed by reflection, and we may confine our attention to the effect of the incident wave. Of course there will also be increased pressure on the rear surface due to the diffracted waves, but this will not affect the pressure on the front surface. At the instant that the wave front strikes the surface imagine the whole wave length divided into thin strips parallel to the surface, s in number and each of thickness x, so that sx is equal to one wave-length. The velocities of displacement due to the wave are mass effects, but it seems proper to add them to the different individual velocities of the gas molecules which move *en masse*. Let the velocities of wave displacement in the successive strips be $u_1, u_2, \ldots u_r$. The component velocities of translation of the gas molecules normal to the surface are U_1, $U_2, \ldots U_n$. The two other components contribute nothing to the pressure on the surface. The resultant velocity of the molecules having a velocity of translation U_1 in the first strip will be $U_1 + u_1$. As they are reflected with the same velocity, the change of momentum of each molecule is

$$2m(U_1 + u_1) = f.dt,$$

where m is the mass of each molecule and $f.dt$ the impulse of the force during collision. If N_1 is the number of molecules per unit volume having the velocity U_1, the number in the strip of thickness x is N_1x and if t_1 is the time required for the strip to move a distance x,

$$N_1x = N_1(U_1 + u_1)t_1.$$

Taking account of the fact that half the molecules of this class will be moving away from the surface, the total change of momen-

[1] "Wärmestrahlung," 2d ed., p. 58.

[2] *Phil. Mag.*, 3, 338, 1902.

[3] *Ann. der Phys.*, 11, 405, 1903.

tum of all the molecules of this class during the time t_1 is

$$N_1 m(U_1 + u_1)^2 t_1 = \Sigma f.dt.$$

The average pressure during the interval t_1 is $\Sigma f.dt/t_1$, therefore,

$$N_1 m(U_1 + u_1)^2 = p_1.$$

Similarly for all the strips as they successively strike the surface up to the last, where

$$N_1 m(U_1 + u_s)^2 = p_s.$$

Squaring and adding for all values of u from u_1 to u_s,

$$N_1 m(sU_1^2 + 2U_1 s\Sigma u_s + \Sigma u_s^2) = \Sigma p_s.$$

But Σu_s throughout the wave is zero, $\Sigma p/s$ is the average pressure during the impact of the whole wave, and $\Sigma u^2/s$ is u^2, the mean square velocity due to vibration, hence after dividing by s,

$$N_1 m(U_1^2 + u^2) = P_1$$

and the same is true of all the other classes of molecules with velocities from U_1 to U_n. If the total number of molecules of all classes is $N_1 = N_1 + N_2 + N_3$, etc., the final resultant effect after adding all the expressions for P_n will be

$$Nm(U^2 + u^2) = \Sigma P_n = P,$$

where U^2 is the mean square translational velocity $= \Sigma N_n U_n^2/N$. The kinetic theory shows that the pressure is NmU^2 when no sound waves are passing. Hence the increased pressure due to the waves is

$$Nmu^2 = \rho u^2,$$

where ρ is the density of the gas.

If the equation of the wave motion is

$y = a \cos (2\pi/\lambda)(x - Vt)$,

$u = dy/dt = a(2\pi/\lambda) V \sin (2\pi/\lambda)(x - Vt)$,

and, since the mean value of $\sin^2$ is 1/2,

$$u = \tfrac{1}{2}a^2(2\pi/\tau)^2 = \tfrac{1}{2}a^2\omega^2,$$

and the pressure due to the waves is $\rho u^2 = \frac{1}{2}\rho a^2\omega^2$, which also represents the maximum kinetic energy or mean total energy of the waves per unit volume, in agreement with Rayleigh's conclusion.

The same result might have been reached directly by assuming that the pressure of a gas is proportional to the mean square velocity of the molecules, however that velocity may be produced. The symmetrical positive and negative values of u would cause the products $U_n u_s$ to vanish in forming the squares of the resultant velocities, so that u^2 would be the increase in the mean square velocity, leading to the same result as that given above.

When we consider the propagation of sound waves in air in molecular rather than in mass terms the expression potential energy loses its meaning. The entire energy of the waves may be expressed in terms of molecular kinetic energy. The conclusion that $p = \rho u^2$ is equivalent to saying that the pressure due to sound waves is equal to twice the mean density of kinetic energy in the medium. When stated in this form, the results agree with those obtained by Planck for the corpuscular theory. The mean kinetic energy is twice as great in one case as in the other.

In the case of stationary waves, the energy density is evidently twice as great as in the incident waves alone; and the mean square velocity from node to node deduced from the mathematical expression for the wave disturbance, and hence the pressure, is likewise twice as great.

The absolute temperature of a gas is proportional to the mean square velocity of the molecules. Ordinarily we should limit this relation to the case where the motion is entirely chaotic, not *en masse*. In either progressive or stationary waves there is an increased mean square velocity in the direction of propagation which would record itself as an increase of temperature on any measuring instrument. In particular, at the loops of stationary waves where there are no density changes no lateral change of pressure would occur, while in the direction in which the waves travel there would be an increase of mean square velocity. In a sense there would be a state of polarized temperature. A thin bolometer strip would undoubtedly indicate a higher temperature when the waves are inci-

dent on its flat side than when they are incident on its edge. The maximum sound-wave pressure found by Altberg, for very intense stationary waves, was about .26 dyne. Since the pressure of a gas is proportional to the absolute temperature, $dT/T = dP/P$. From this it may be calculated that the increase of temperature indicated by a thin bolometer strip on which the waves exert a pressure of .26 dyne would be about .000075° at atmospheric pressure and a temperature of 17° C. or 290° absolute.

E. P. Lewis

University of California

RUDIMENTARY MAMMÆ IN SWINE A SEX-LIMITED CHARACTER[1]

The inheritance of the rudimentary mammæ found on the lower part of the scrotum of the boar and on the inside of the thighs to the rear of the inguinal pair in the sow, was reported as typically sex-limited by the writer in 1912 and 1913. Later, in 1914, due to the failure to discover a boar homozygous for the character, an attempt was made to classify the inheritance as sex-linked in nature. Certain more recent discoveries, due largely to a few selected matings, have cleared up the difficulties which in 1914 were believed to exist, and make the earlier interpretation more probable.

The case in point is as follows: A Duroc Jersey boar possessing the rudimentaries was mated to a grade black sow lacking them. A litter of nine pigs was farrowed, four of the boars having rudimentaries, and one lacking them, while three of the sows lacked rudimentaries and the fourth possessed them. Coupled with the evidence on the inheritance of this character published previously, this breeding performance indicates that both the Duroc Jersey boar and the grade black sow were heterozygous for this character.

One of the boars possessing rudimentaries from this litter was mated to the four sows of the litter with the following results:

[1] Paper No. 2 from the Laboratory of Animal Technology, Kansas Agricultural Experiment Station.

Record Number	Apparent Hereditary Constitution	Males		Females	
		With Rudimentaries	Without Rudimentaries	With Rudimentaries	Without Rudimentaries
Sow 26......	RR	4	0	3	0
Sow 27......	Rr	4	0	3	2
Sow 28......	rr	3	0	0	2
Sow 29	rr	4	0	0	4

This breeding performance very definitely indicates that the boar was homozygous for the rudimentary mammæ. All of the boar pigs that he sired possessed the character, even though two of the sows were of a type not to transmit it at all. If he were heterozygous for the character, then at least part of the seven male pigs from sows 28 and 29 should have lacked the rudimentaries; the chances of their all having them being one out of 128. The discovery of a boar homozygous for the rudimentaries removes the principal stumbling block to the simple sex-limited theory.

Davenport and Arkell have developed a scheme which bridges the discrepancies between sex-limited and sex-linked inheritance, even when apparently homozygous animals exist. Since, however, the sex-limited explanation advanced by Wood seems to cover all the facts that are involved in this case, and since it is much simpler, the writer prefers thus to interpret these results.

Edward N. Wentworth

LITERATURE CITED

Arkell, T. R., and Davenport, C. B. Horns in Sheep as a Typical Sex-limited Character. Science, N. S., Vol. 35, pp. 375–377.

Wentworth, E. N. Another Sex-limited Character. Science, N. S., Vol. 35, p. 986.

Inheritance of Mammæ in Duroc Jersey Swine. *Amer. Nat.*, Vol. 47, pp. 257–278.

Inheritance of Rudimentary Mammæ in Swine. *Proc. Iowa Acad. Sci.*, 1914, Vol. 21, pp. 265–268.

Wood, T. B. Note on the Inheritance of Horns and Face Color in Sheep. *Jour. Agr. Sci.*, Vol. 1, p. 364.

THE NATIONAL ACADEMY OF SCIENCES

The sessions of the annual meeting of the National Academy of Sciences were held in the United States National Museum, Washington,

D. C., on April 17, 18, 19, 1916. Seventy-two members were present as follows:

Charles Greeley Abbot, J. Asaph Allen, J. S. Ames, George F. Becker, B. B. Boltwood, Nathaniel Lord Britton, Henry Andrews Bumstead, D. H. Campbell, Walter Bradford Cannon, J. McKeen Cattell, W. B. Clark, F. W. Clarke, J. M. Clarke, George C. Comstock, E. G. Conklin, J. M. Coulter, Whitman Cross, William H. Dall, C. B. Davenport, W. M. Davis, Arthur L. Day, H. H. Donaldson, Jesse Walter Fewkes, Simon Flexner, Arnold Hague, George E. Hale, E. H. Hall, R. A. Harper, John F. Hayford, W. F. Hillebrand, W. H. Holmes, W. H. Howell, Joseph Iddings, Herbert Spencer Jennings, Armin Otto Leuschner, F. R. Lillie, Jacques Loeb, Graham Lusk, F. P. Mall, S. J. Meltzer, Lafayette B. Mendel, C. Hart Merriam, Ernest Merritt, Robert A. Millikan, E. H. Moore, Edward W. Morley, H. N. Morse, F. R. Moulton, E. L. Nichols, A. A. Noyes, George H. Parker, Edward C. Pickering, M. I. Pupin, F. L. Ransome, H. Fielding Reid, Ira Remsen, Edward B. Rosa, Charles Schuchert, William B. Scott, E. F. Smith, William E. Story, C. R. Van Hise, E. B. Van Vleck, Charles D. Walcott, Arthur G. Webster, William H. Welch, William M. Wheeler, David White, H. S. White, Edmund B. Wilson, R. W. Wood, R. S. Woodward.

The following scientific program was carried out in full:

MONDAY, APRIL 17

Morning Session

"On Permeability of *Endothelia*," by S. J. Meltzer.

"The Influence of Morphin upon the Elimination of Intravenously Injected Dextrose," by I. S. Kleiner and S. J. Meltzer.

"The Sex of a Parthenogenetic Frog," by Jacques Loeb.

"The Distribution of the Chondrosomes to the Spermatozoa in Scorpions," by Edmund B. Wilson.

Symposium on the Exploration of the Pacific

Arranged by W. M. Davis (by invitation of the Program Committee)

"On Exploration of the Pacific," by W. M. Davis.

"The Importance of Gravity Observations at Sea in the Pacific," by J. F. Hayford.

"A New Method of Determining Gravity at Sea," by L. J. Briggs, president of the Philosophical Society of Washington.

"The Problem of Continental Fracturing and Diastrophism in Oceanica," by C. Schuchert.

"Petrological Problems in the Pacific," by J. P. Iddings.

Afternoon Session

"A New Form of Metamorphism," by Arthur Keith (introduced by George F. Becker).

"Contributions to the Petrology of Japan, Philippine Islands and the Dutch Indies," by J. P. Iddings and E. W. Morley.

Symposium on the Exploration of the Pacific (Continued from the Morning Session)

"The Extent of Knowledge of the Oceanography of the Pacific," by G. W. Littlehales, Hydrographic Engineer, United States Hydrographic Office.

"Marine Meteorology and the General Circulation of the Atmosphere," by C. F. Marvin, Chief of the United States Weather Bureau.

"On the Distribution of Pacific Invertebrates," by Wm. H. Dall.

"Land Mollusca of the Pacific," by H. A. Pilsbry, Academy of Natural Sciences of Philadelphia.

"Marine Algæ of the Pacific," by W. G. Farlow.

"Problems of the Pacific Floras," by D. H. Campbell.

"The Pacific as a Field for Anthropological Investigation," by J. W. Fewkes.

Papers of the Regular Program

"Hereditary Transmission of Defects resulting from Alcoholism," by Charles R. Stockard. (By invitation of the Program Committee.)

"Recent Observations on the Activity of some Glands of Internal Secretion," by W. B. Cannon.

"Studies in the Water Content of the Nervous System," by H. H. Donaldson.

First William Ellery Hale Lecture, by Henry Fairfield Osborn, President of the American Museum of Natural History. Subject: "The Origin and Evolution of Life on the Earth." (Illustrated.)

The lecture was followed by a conversazione in the art gallery of the museum.

TUESDAY, APRIL 18

Morning Session

"Some Recent Results of Solar Research," by George E. Hale.

"An Investigation of the Suggested Mutual Repulsion of Fraunhofer Lines," by Charles E. St. John (introduced by G. E. Hale).

"Anomalous Dispersion Phenomena in Electric Furnace Spectra," by Arthur S. King (introduced by G. E. Hale).

"Illustrations of the New Spectroscopic Method of Measuring Stellar Distances," by Walter S. Adams (introduced by G. E. Hale).

"Some Results with the New 10-inch Photographic Telescope," by Harlow Shapley (introduced by G. E. Hale).

"The Pyranometer, an Instrument for the Measurement of Sky Radiation," by C. G. Abbot and L. B. Aldrich.

"Invisible Companions of Binary Stars," by G. C. Comstock.

"Theory of Electric Conduction in Metals," by Edwin H. Hall.

"The Evolution of the Stars," by F. R. Moulton.

"The Minor Planets discovered by James C. Watson," by A. O. Leuschner.

Afternoon Session

"Biography of Professor Theodore Nicholas Gill," by Wm. H. Dall. (By title.)

"Biography of Professor Edward Singleton Holden," by W. W. Campbell. (By title.)

"Biography of Professor Simon Newcomb," by W. W. Campbell. (By title.)

"Biography of John Shaw Billings," by Fielding H. Garrison. (By title.)

"Report of the Work of the Committee upon the Panama Canal Slides," by Charles R. Van Hise, chairman.

"The Mechanics of the Panama Slides," by H. Fielding Reid.

"The Present State of Knowledge of the Extreme Ultra-violet," by Theodore Lyman, Director Jefferson Physical Laboratory, Harvard University. (By invitation of the Program Committee.)

"A Redetermination of e and N," by Robert A. Millikan.

"The Relation of Investigational Work to the Enforcement of the Food and Drugs Act," by Carl L. Alsberg. (By invitation of the Program Committee.)

"Recent Exploration on the Mesa Verde National Park," by J. Walter Fewkes.

"Further Evidence on the Nature of Crown Gall and Cancer and that Cancer in plants offers strong presumptive evidence both of the parasitic origin and of the essential unity of the various forms of Cancer in man and animals," by Erwin F. Smith.

Wednesday, April 19

Second William Ellery Hale Lecture, by Henry Fairfield Osborn, President of the American Museum of Natural History. Subject: "The Origin and Evolution of Life on the Earth." (Illustrated.)

PRESENTATION OF MEDALS

At the annual dinner of the academy held at the Hotel Raleigh on April 18, 1916, the medals for eminence in the application of science to the public welfare were awarded to Cleveland Abbe and to Gifford Pinchot, and the James Craig Watson medal was awarded to Armin Otto Leuschner.

The president announced the following deaths since the last annual meeting of the academy:

John Ulric Nef, died on August 13, 1915, elected in 1904.

Frederic Ward Putnam, died on August 18, 1915, elected in 1885.

Arthur W. Wright, died on December 19, 1915, elected in 1881.

Eugene W. Hilgard, died on January 8, 1916, elected in 1872.

The reports of the president and treasurer for the year 1915 were presented to the academy in printed form as transmitted to the Senate of the United States by the president of the academy.

REPORT OF THE HOME SECRETARY

The President of the National Academy of Sciences.

Sir: I have the honor to present the following report on the publications and membership of the National Academy of Sciences for the year ending April 19, 1916.

The *Memoirs of the National Academy of Sciences*, Volume 12, part 2, entitled "Variations and Ecological Distribution of the Snails of the Genus *Io*," by Charles C. Adams, has been published and distributed, as has also the memoir forming Volume 12, being "A Catalogue of the Meteorites of North America," by Oliver C. Farrington. Volume 14, memoir 1, entitled "Report on Researches on the Chemical and Mineralogical Composition of Meteorites, with Especial Reference to their Minor Constituents," by George Perkins Merrill, is going through the press and the final proof has been passed. It awaits casting and printing before it is published.

The biographical memoirs of John W. Powell, Miers Fisher Longstreth, Charles Anthony Schott, Peter Lesley, Henry Morton and Alfred Marshall Mayer have been published, and that of George William Hill, by Ernest W. Brown, has also been published but not distributed.

Three members have died since the last annual meeting: John Ulric Nef, on August 13, 1915, elected in 1904; Frederic W. Putnam, on August

18, 1915, elected in 1885; and Eugene W. Hilgard, on January 8, 1916, elected in 1872.

One foreign associate, Paul Ehrlich, died on August 20, 1915, elected in 1904.

There are 139 active members on the membership list, 1 honorary member, and 39 foreign associates.

ARTHUR L. DAY,
Home Secretary

REPORT OF THE FOREIGN SECRETARY

I have the honor to report on the work of the foreign secretary for the year ending April 19, 1916.

An attempt has been made, through correspondence with various academies and societies belonging to the International Association of Academies, to secure a partial continuance of some portions of the association's work through the period of the war. Although international meetings are obviously not feasible, it was hoped that a temporary transfer of the functions of leading academy from Berlin to Amsterdam, as suggested by the former body, might serve a useful purpose. Unfortunately, however, certain difficulties of an insuperable nature prevented the proposed transfer, and no further steps can be taken at present.

It was suggested to the Amsterdam Academy by the foreign secretary, also acting in the capacity of secretary of a joint committee of the National Academy and the American Association, that the Accademia dei Lincei be requested to use its good offices to secure the continuation of the work of the Zoological Station at Naples. A favorable reply was received from the president of the Lincei, but the participation of Italy in the war has prevented Dr. Dohrn from retaining the direction of the station, which is now under an Italian administration.

At the request of the president of the Amsterdam Academy, who is also permanent secretary of the International Geodetic Association, the Secretary of State was asked by the academy to use his influence to secure the continued participation of the United States in the work of the association, and the maintenance of the international latitude station at Ukiah, California. Through the action of the Secretary of State, and the interest of members of Congress, the necessary appropriations have been provided.

GEORGE E. HALE,
Foreign Secretary

The following reports from the directors of the trust funds of the academy were presented and the recommendations contained therein adopted.

REPORT OF THE DIRECTORS OF THE BACHE FUND

Mr. Ira Remsen resigned as director of the fund at the annual meeting, 1915. The two remaining members of the committee chose Mr. Arthur G. Webster as the third member, and later the undersigned was elected chairman. Since the annual meeting the following appropriations have been made:

No. 187 to H. H. Lane, State University of Oklahoma, $500, for the purchase of apparatus to be used in a comparative study of the embryos and young of various mammals in order to determine, by physiological experimentation and morphological observations, the correlation between structure and function in the development of the special senses.

No. 188 to H. W. Norris, Grinnell College, $100, for assistance in the analysis of the cranial nerves of Cœcilians (*Herpele* and *Dermophis*).

No. 189 to E. J. Werber, Woods Hole, $230, for assistance in experimental studies aiming at the control of defective and monstrous development: (1) the effect of toxic products of metabolism on the developing teleost egg; (2) the effect of experimentally produced diseases of parental metabolism on the offspring of mammals.

No. 190 to H. S. Jennings, Johns Hopkins University, $200, for assistance in the study of evolution in a unicellular animal multiplying by fission: heredity, variation, racial differentiation in *Difflugia*.

No. 191 to P. W. Bridgman, Harvard University, $500, for mechanical assistance in an investigation of various effects of high hydrostatic pressure, in particular the effect of pressure on electrical resistance of metals (continuation).

No. 192 to J. P. Iddings, Washington, D. C., $1,000, for apparatus and assistance in the microscopical and chemical investigation of igneous rocks for the purpose of extending knowledge regarding petrographical provinces and their bearings on the problem of isostasy.

No. 193 to C. A. Kofoid, University of California, $500, for assistance in securing animals in the Indian jungle and in their preparation for study in research on the intestinal protozoa.

No. 194 to R. A. Daly, Harvard University, $1,000, for the purchase of a thermograph of new design for determining temperatures in the deep sea.

No. 195 to R. W. Hegner, University of Michigan, $160, for assistance in the study of the history of the germ-cells, especially in hermaphrodite animals in order to determine the visible changes that take place in their differentiation and the causes of these changes (continuation).

The following information has been received concerning earlier grants:

No. 183. A report has been received from C. G. Abbot, describing the successful operation of the apparatus constructed with this grant. This closes the record of this award.

No. 184. Papers have been published by P. W. Bridgman on work done with the aid of this grant as follows: "Change of Phase under Pressure," *Physical Review*, N. S., VI., July and August, 1915. "Polymorphic Transformation of Solids Under Pressure," *Proceedings of the American Academy of Arts and Sciences*, II., September, 1915. This closes the record of this award.

The treasurer of the academy states, under date of April 7, 1916, that the Bache Fund has on hand a cash income balance of $980.62, together with an invested income of $2,575.

Respectfully submitted,

EDWIN B. FROST,
Chairman

REPORT OF THE COMMITTEE ON THE HENRY DRAPER FUND

Four members of the committee, without consulting the fifth member (Professor Michelson), recommended that the Henry Draper Gold Medal be awarded to Professor A. A. Michelson, of the University of Chicago, for his numerous and important contributions to spectroscopy and astronomical physics.

It is impossible in the brief space of this report even to enumerate Professor Michelson's major services to science. These include the precise determination of the velocity of light; the well-known experiment (with Professor Morley) on ether drift; the measurement of the absolute wave-length of light involved in his determination of the length of the standard meter; the measurement of tides in the body of the earth with new apparatus of extraordinary precision; and the invention of the interferometer, the echelon, and other instruments of prime importance to the student of light. He has also constructed a ruling machine yielding diffraction gratings of the longest size and the highest resolving power yet attained, and carried on a multiplicity of researches of wide range and fundamental significance.

The committee also recommends that a grant of $250 be made to Professor Philip Fox, director of the Dearborn Observatory, of Northwestern University, Evanston, Illinois, to apply toward the cost of a machine for measuring astronomical photographs.

Regarding previous grants from the Draper Fund, the committee begs to report that the grant to Dr. C. G. Abbot has been expended for computer's services in an investigation which has established the variability of distribution of radiation along the sun's diameter. Grants to Messrs. Campbell, Mitchell, Stebbins and Schlesinger, respectively, for the construction of instruments or the prosecution of researches not yet completed.

George E. Hale,
Chairman

REPORT OF THE TRUSTEES OF THE WATSON FUND

The balance of the income of the Watson Fund, available for appropriation, on April 1, 1916, was $1,070.15. The undersigned accordingly recommend the following votes:

Resolved, That the sum of five hundred dollars from the income of the Watson Fund be appropriated to Professor John A. Miller, director of the Sproul Observatory, for measuring plates already taken for the determination of stellar parallaxes. (Grant No. 10.) This is a continuation of Grant No. 10 awarded last year. A report of the work accomplished is enclosed.

Resolved, That the sum of three hundred dollars from the income of the Watson Fund be appropriated to Professor Herbert C. Wilson, director of the Goodsell Observatory, for measurements of the positions of asteroids on photographs already taken. (Grant No. 12.)

In each of these cases, material has already been collected whose preparation independently would involve a large expenditure. A relatively small sum will thus complete the work and secure the results for which the investigations were undertaken.

Edward C. Pickering,
W. L. Elkin,
Edwin B. Frost

REPORT OF THE COMMITTEE ON THE J. LAWRENCE SMITH FUND

The Committee on the J. Lawrence Smith Fund reports as follows:

No. 3. Edmund Otis Hovey, curator in the department of geology and invertebrate paleontology in the American Museum of Natural History, New York, received in 1909 a grant of $400 to aid in the study of certain meteors. He has for some time been with an expedition to the Arctic regions, so that the work is not at the moment making progress.

No. 4. C. C. Trowbridge, professor of physics in Columbia University, New York, received in 1909 a grant of $400 in aid of his studies of the luminous trains which are produced by some meteors. A further grant of $1,000 in four annual installments was voted by the Academy in 1912. Good progress has been made in the tabulation of all existing records of such luminous trains and in the preparation of illustrations of them, as well as in other directions. Owing to conditions in Europe the last installment of $250, available a year ago, has not yet been called for.

No. 5. George P. Merrill, head curator in the department of geology in the United States National Museum, has received grants in 1910, 1911 and 1913, amounting to $800, to aid in verifying the occurrence in some meteors of certain rare elements. This work has been very successfully completed, abstracts of results obtained have been presented to the academy, and the final report forms pages 1–26 of the *Memoirs* of the academy, Vol. 14, just issuing from the press, and closing the record of this grant.

No. 6. S. A. Mitchell, professor in the University of Virginia, University, Va., received in 1915 a grant of $500 to aid in securing observations of paths and of radiants of meteors and in computing orbits where observations are sufficient. Maps in aid of such observations have been placed at the service of volunteer observers, and nearly 5,000 observations of meteor paths have been secured. These observations, as well as a good number otherwise secured, have been discussed and have yielded some parabolic orbits.

The committee is unanimous in recommending that a further grant of $300 be made to carry on this valuable work.

The Lawrence Smith Fund now has a cash balance of income of $834.77 of which $250 is already appropriated, though not yet paid over. The cash income balance available is therefore $784.77. There is also an invested income balance of $1,532.50.

For the Committee,
EDWARD W. MORLEY,
Chairman

REPORT OF THE COMMITTEE ON THE COMSTOCK FUND

The committee on the Comstock Fund begs to report that, according to the statement of the treasurer of the National Academy of Sciences, the total income from the fund now available is $1,661.32.

The next award will be made at the end of the five-year period specified in the bequest, *i. e.*, at the annual meeting in April, 1918.

EDW. L. NICHOLS,
Chairman

April 18, 1916

REPORT OF THE DIRECTORS OF THE WOLCOTT GIBBS FUND

The directors of the Wolcott Gibbs Fund for Chemical Research respectfully submit the following report for the year 1915 to 1916 to the National Academy of Sciences.

On April 29, 1915, President Ira Remsen resigned from the board, to the great regret of his colleagues.

On May 18 Professor T. W. Richards was elected to fill the vacancy caused by President Remsen's withdrawal.

Only one appropriation has been made from the income of the fund this year—a grant (No. 6) to Professor Gregory P. Baxter, of Cambridge, of $300 to provide apparatus especially of platinum and quartz and materials for his researches on atomic weights and changes of volume during solution.

The unexpended income of the fund is $90.77.

Satisfactory reports have been received from holders of previous grants.

Grants 2 and 5. Professor Mary E. Holmes has a paper in press on "The Electro-Deposition of Copper from the Ammoniacal Cyanide Electrotype." Progress has also been made in the study of the deposition of cadmium and its separation from other elements.

Grant 3. Professor W. J. Hale has finished his work on the cyclopentadiopyridazine except for a few less important details. He hopes in June to have the paper ready for publication.

Grant 4. Professor W. D. Harkins has determined the freezing-point lowerings for thirteen salts in aqueous solutions, nine of which are cobaltammines; and has begun the study of mixtures of salts.

(Signed) C. L. JACKSON,
EDGAR F. SMITH,
T. W. RICHARDS,
Directors

April 6, 1916

REPORT OF THE COMMITTEE ON THE MURRAY FUND

SECRETARY, NATIONAL ACADEMY OF SCIENCES.

Sir: The Committee on the Sir John Murray Fund has to report that the unusual expenses due to the designing and striking off of the Agassiz medal, as called for by the terms of the gift, has required all the early income. The Committee deemed best not to touch the original fund, and the income from the fund was not sufficient to meet these expenses. All these expenses have now been met, but there is no cash balance and no invested income. This income has been applied to the payment of the amount advanced from the General Fund, but from now on the interest from the fund will be applied as originally intended, for the striking off of the Agassiz medal and contributions to oceanography.

ARNOLD HAGUE,
Chairman

REPORT OF THE COMMITTEE ON THE BILL, H. R. 528, TO DISCONTINUE THE USE OF THE FAHRENHEIT THERMOMETER SCALE IN GOVERNMENT PUBLICATIONS

Your committee for the consideration of Bill H. R. 528, consisting of Messrs. C. G. Abbot, S. W.

Stratton and C. F. Marvin, unanimously reports the following resolution, and moves its adoption.

The National Academy of Sciences shares the desire of scientific men in general for international and world-wide uniformity in units of measurement of all kinds, and with this object in view it favors the introduction of the Centigrade scale of temperature, and units of the metric system generally, as standards in the publications of the United States government.

It must be recognized that considerable initial expense must be incurred by the U. S. Weather Bureau in changing its apparatus to conform to the proposed act. Furthermore, on account of the more open scale of the Centigrade system that Bureau will be subject to a continued cost of publication, owing to the necessity of printing the first decimal place in order to maintain the present accuracy. The use of negative temperatures and minus signs entails greater liability to errors, and more clerical labor would be required in checking the accuracy of the reports of cooperative observers of the Weather Bureau, and in computing monthly and other mean temperatures.

Notwithstanding the foregoing, the Academy is in favor of legislation to make the Centigrade scale of temperatures the standard in publications of the United States government, and funds should be made available by Congress to accomplish the desired result.

The Academy favors Bill H. R. 528, "To discontinue the use of the Fahrenheit thermometer scale in government publications," but recommends that it be amended by the addition of the following:

Sec. 4. When in the publication of tables containing several meteorological and climatic elements, the use of data in Centigrade temperatures leads to manifest incongruities, the chief of the Weather Bureau is directed to publish related data in such units as are necessary to make the tables homogeneous and to secure international uniformity as far as practicable.

Sec. 5. Nothing in this act shall prevent the use of the absolute Centigrade scale of temperature in publications of the government.

Upon recommendation of the Council the following minute was adopted:

That in accordance with the request of the chairman of the Committee on Foreign Affairs of the House of Representatives a committee of the Academy be appointed to prepare a report upon the joint resolution (H. J. Res. 99), "That the President be, and he is hereby, requested to ascertain the views of foreign governments regarding the proposition to appoint an international commission to prepare a universal alphabet," and that the report be submitted to the president of the academy, who in turn will transmit it to the chairman of the Committee on Foreign Affairs of the House of Representatives, reporting his action in the matter at the next annual meeting of the Academy.

Messrs. Cattell, Bell, Boas, Dewey and Lindgren were appointed members of this committee.

The council also recommended to the academy the appointment of a committee to discuss possible plans of cooperation with a committee of engineers. The following committee was appointed: George E. Hale, chairman, J. S. Ames, John F. Hayford, E. L. Nichols, M. I. Pupin, E. B. Rosa, Elihu Thomson, C. R. Van Hise, C. D. Walcott, R. S. Woodward.

The president announced that an invitation had been received from the members of the Academy living in Boston that the Academy hold its autumn meeting in the year 1916 in that city. The following members were appointed to serve as a local committee of this meeting: William M. Davis, chairman, W. T. Councilman, Arthur A. Noyes, George H. Parker, E. C. Pickering.

Mr. George E. Hale was reelected foreign secretary of the academy for a term of six years.

Mr. R. H. Chittenden and Mr. M. I. Pupin were elected members of the council for a term of three years.

New members of the academy were elected as follows:

Gilbert Ames Bliss, University of Chicago, Chicago, Illinois.

Frank Schlesinger, University of Pittsburgh, Pittsburgh, Pa.

Gregory Paul Baxter, Harvard University, Cambridge, Mass.

Marston Taylor Bogert, Columbia University, New York City.

Leland Ossian Howard, U. S. Department of Agriculture, Washington, D. C.

Alfred Goldsborough Mayer, Carnegie Institution, Tortugas, Florida.

Raymond Pearl, Maine Agricultural Experiment Station, Orono, Maine.

Phoebus Aaron Theodor Levene, Rockefeller Institute for Medical Research, New York City.

Otto Folin, Harvard Medical School, Boston, Mass.

ARTHUR L. DAY,
Home Secretary